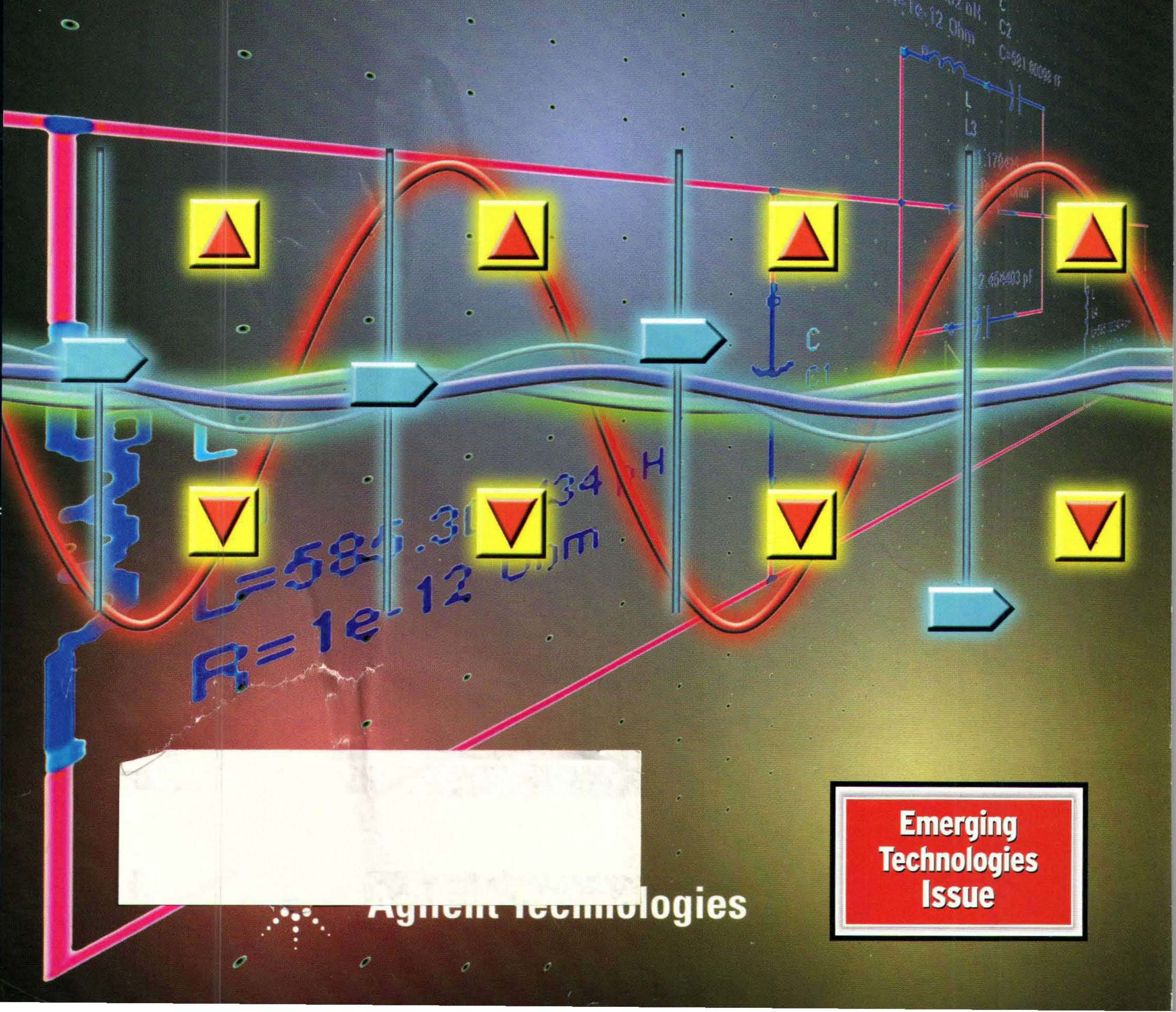
Microwaves & RF

News
Emerging technologies benefit creative designers

Design Feature
Size up acceleration sensitivity on XOs

Product Technology
HBT devices deliver gain/linearity to 2.4 GHz

EDA Software's Ease Of Use Belies Power



Emerging Technologies Issue

JCA TECHNOLOGY

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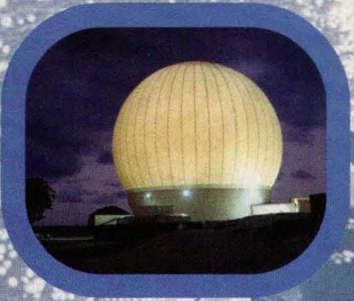
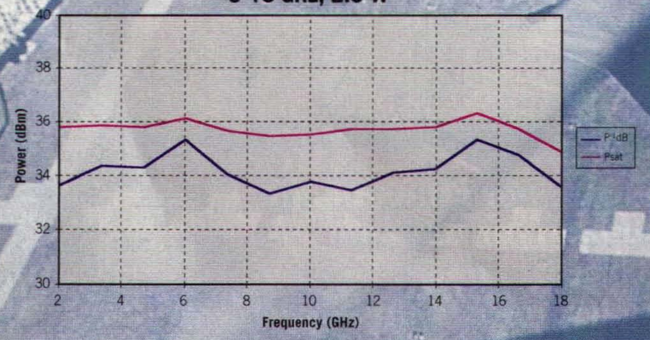


Model dB min	Freq. Range dB min	Gain dB min	Flatness +/–dB	1 dB Comp. pt. dBm min	N/F Max	3rd Order ICP typ	VSWR In/Out Max
LNA's							
JCA12-3001	1.0–2.0	40	1.0	10	**0.8**	20	2.0
JCA24-3002	2.0–4.0	40	1.0	10	**1.0**	20	2.0
JCA48-4001	4.0–8.0	42	1.5	15	**1.0**	25	2.0
JCA812-5001	8.0–12.0	45	1.5	10	**1.5**	20	2.0
JCA1218-5002	12.0–18.0	48	1.5	10	**1.5**	20	2.0
Ultra Low Noise Amplifiers							
JCA45-306	4.5–4.8	40	0.5	10	**0.5**	20	2.0
JCA45-305	4.4–5.1	30	0.5	10	**0.7**	20	2.0
JCA56-309	5.4–5.9	30	0.5	10	**0.7**	20	2.0
JCA78-306	7.25–7.75	30	0.5	10	**0.7**	20	2.0
JCA12-3040	1.2–1.6	30	0.5	10	**0.7**	20	2.0
Broadband Power Amplifiers							
JCA618-4001	**6.0–18.0**	40	1.5	**33**	3.0	40	2.0
JCA218-3002	2.0–18.0	34	2.0	**27**	4.0	33	2.0
JCA218-4002	2.0–18.0	44	2.5	**27**	4.0	32	2.0
JCA218-5002	2.0–18.0	54	2.5	**27**	4.0	32	2.0
JCA218-3001	2.0–18.0	30	2.0	**25**	4.0	30	2.0

Low Phase Noise Amplifiers

Carrier Offset	C, X-Band (-dBc/Hz)	Ku-Band (-dBc/Hz)
100 Hz	**135**	**125**
1.0 kHz	**145**	**142**
10 kHz	**153**	**150**
100 kHz	**158**	**152**

6-18 GHz, 2.0 W



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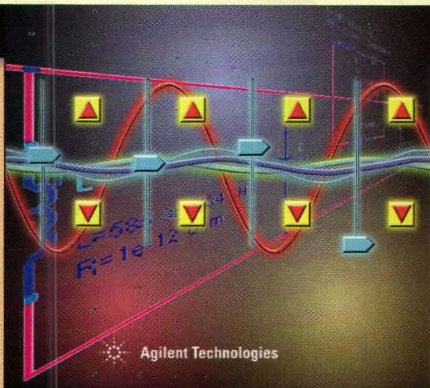
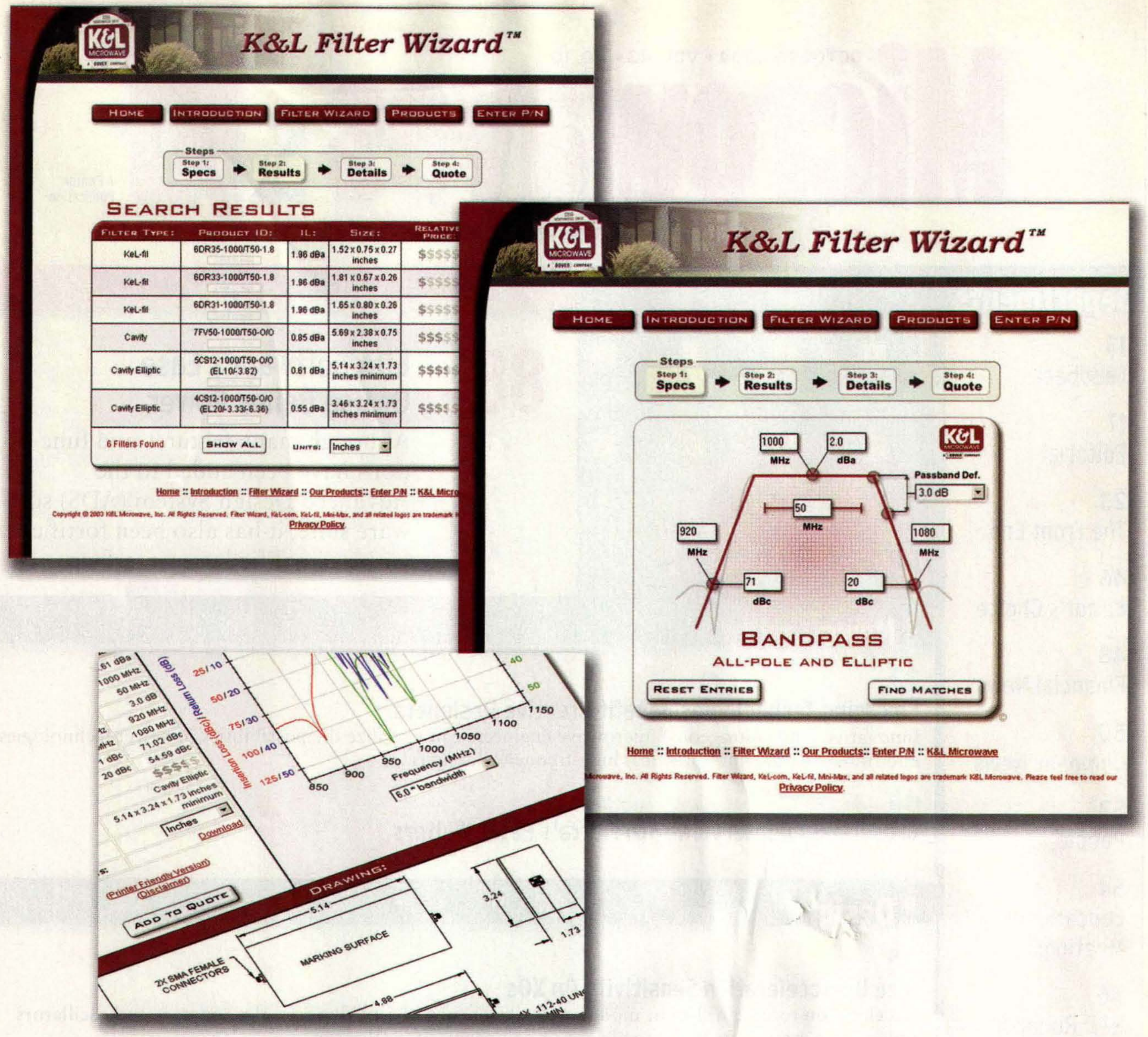


COVER STORY

News

Design

Product Technology



simplicity...

Designing a communications network, RF Sub-assembly or military system is, in a way, like completing a puzzle. Piece by piece you search for the components that offer the highest quality, state-of-the-art features, competitive pricing and most importantly...compatibility. After all, if they don't work together then the puzzle isn't complete.

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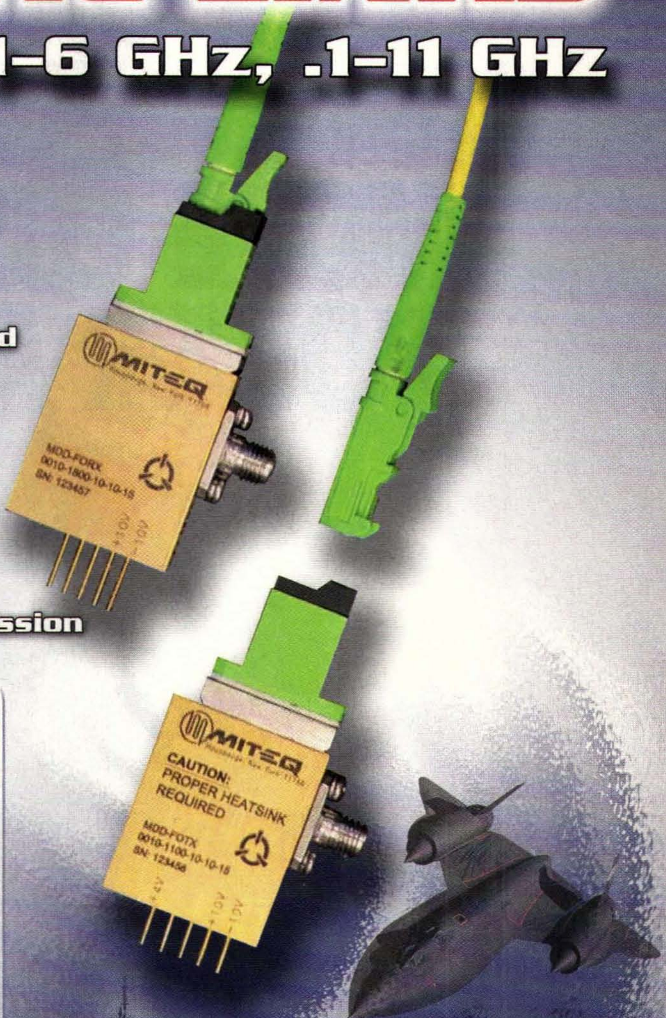
.01–3 GHz, .1–6 GHz, .1–11 GHz



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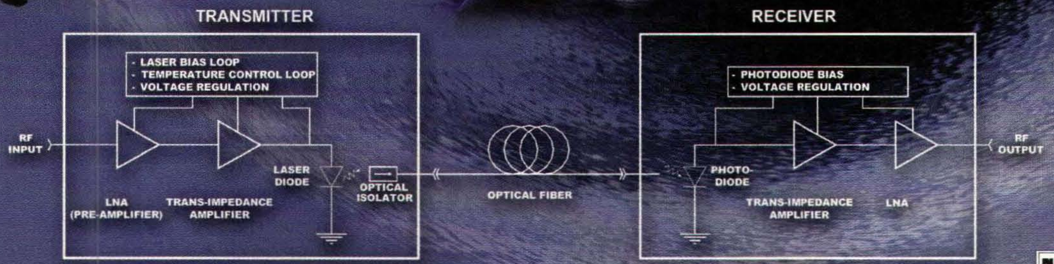
- Local Oscillator Remoting
- Aircraft & Shipboard Signal Transmission

Electrical Specifications
(1 Meter of Fiber)

Model	LBL	SCM	MDD
Frequency (GHz)	.01–3	0.1–6	0.1–11
Gain (dB)	10-20 (17 Typ.)	10-20 (18 Typ.)	10-20 (18 Typ.)
Noise Figure (dB, Max.)	15 (10 Typ.)	20 (14 Typ.)	20 (18 Typ.)
Group Delay (ns ptp, Typ.)	0.1	0.1	0.1
VSWR (In/Out)	2:1	2:1	2:1
Phase Noise (dBc, Typ.)	>100	>100	>100
Input Power @P1dB (dBm, Min.)	-14	-14	-14
Spurious Free Dynamic Range (dB/Hz, Min.)	100 (105 Typ.)	101 (103 Typ.)	100 (104 Typ.)



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Words Of Appreciation

▶▶I WAS THRILLED to see the July issue of the *M-RF Product Quarterly* with our PSG line on the cover ("Signal generators extend to 67 GHz," Cover, *M-RF Product Quarterly*, July 2004—Ed.), and the rest of the products from the MTT-S on p. 20. Then there's the coverage of the Frost & Sullivan awards in The Front End section on p. 28 of the July issue of *Microwaves & RF*, and then the E5052A feature on p. 97 of the same issue ("Instrument Evaluates Oscillator Performance," p. 97, *Microwaves & RF*, July 2004—Ed.).

Agilent launched a record number of products in a very tight window, and we all really appreciate your covering them in this fashion. And, apart from the Agilent coverage, I was struck by how robust both *M-RF Product Quarterly* and *Microwaves & RF* were in July. I know it takes a lot of work to get them out the door, but they really looked solid.

Janet G. Smith
US PR Manager
Agilent Technologies

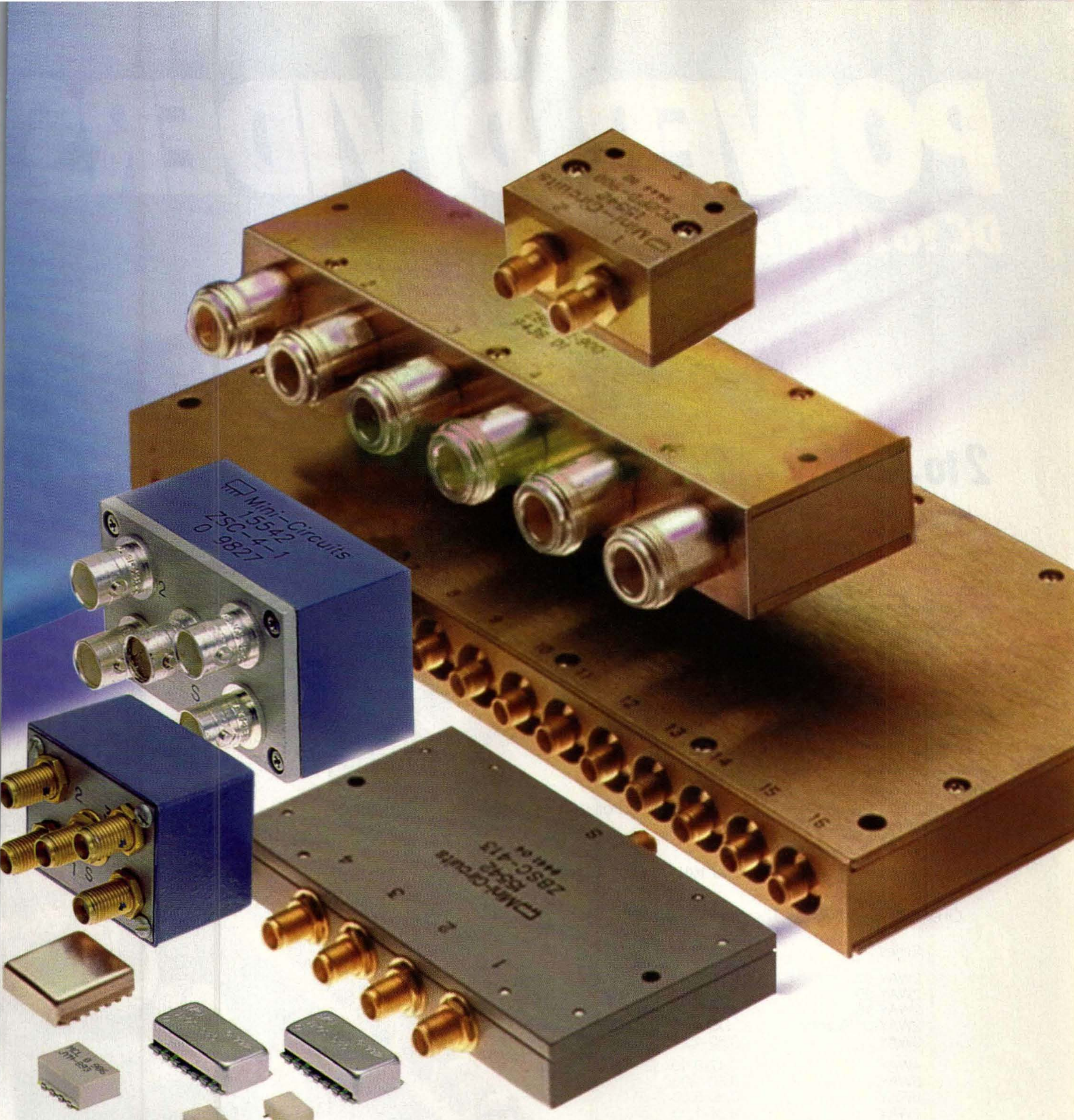
Specsmanship Editorial

▶▶I RECENTLY READ your Editorial titled "Understanding Specsmanship" in the July 2004 issue of *Microwaves & RF* (p. 17). I could not agree more that the industry should standardize how data is presented in order to quickly and accurately compare products.

Over the years, the industry has participated in a well-known "specsmanship" game proclaiming high-performance specifications but delivering less when implemented in real-world applications. Customers' initial tolerance of this is morphing into frustration as the time-to-market pressure for high-performance products increases. As they should, customers are now demanding that companies prove performance with evaluation boards and well-documented data sheets that show performance under real-world operating conditions, rather than ideal or manipulated operating conditions.

The challenge to the industry is to abandon the specsmanship game and deliver more than the status quo, particularly when it comes to analog and mixed-signal performance. The electronics market is too competitive and designers are working too hard to make guesses on how a product will perform. A product that meets the specifications on the data sheet saves time and money while allowing the designer to get back to designing.

Derrell Coker
Vice President, MCU Products
Silicon Laboratories, Inc.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BLUE CELL DESIGNER'S HANDBOOK
RF/IF Designer's Guide

When Do They Finally Emerge?

EMERGING TECHNOLOGIES impact high-frequency electronic designs by providing alternative approaches to achieving a function. The function may be a simple as amplifying a signal, or a complex as restoring lost bits to a data stream. But what determines the acceptance of a new technology? Why do some seemingly innovative technologies fall by the wayside?

Most engineers learn to evaluate new technologies for their practical merit. Semiconductor technologies offer a good example of this. Although silicon bipolar technology served many solid-state high-frequency applications throughout the 1970s and 1980s, it was the considerable investment by DARPA during the latter decade that fostered advances in gallium arsenide (GaAs). Most major defense contractors, such as Boeing, Raytheon, TRW, and the firms that would become component parts of Lockheed Martin and Northrop Grumman participated in DARPA's MIMIC program with the eventual result that the yields of GaAs wafers improved, noise figures dropped, and gain and output-power levels increased. GaAs was also attractive because it lent itself to integration. The growth of wireless markets in the late 1980s and 1990s brought high-volume commercial outlets for GaAs that encouraged increases in wafer sizes. As device designers expanded the technology from early MESFET designs to other structures, such as high-electron-mobility transistors (HEMTs) and heterojunction bipolar transistors, the technology grew to acceptance levels that have all but eclipsed silicon bipolars in high-frequency circuits.

Engineers are practical, and will adopt a new technology if it solves a problem or helps simplify the attainment of a design goal, even if the cost is higher at first.

Would RF and microwave engineers have embraced this relatively new technology if it didn't offer higher gains at higher frequencies than silicon bipolars? It is very unlikely. Engineers are practical, and will adopt a new technology if it solves a problem or helps simplify the attainment of a design goal, even if the cost is higher at first.

A Special Report beginning on p. 33 details some of the more visible emerging technologies currently impacting high-frequency designs, including microelectromechanical systems (MEMS) and ultrawideband (UWB) transmissions. A longer version of the article, available on the *Microwaves & RF* website at www.mwrf.com, includes additional technologies of interest, such as multilayer fabrication technologies and wide-bandgap semiconductors, such as gallium-nitride (GaN) and silicon-carbide (SiC) devices. Not all emerging technologies, such as high-temperature superconductors (HTS), are adopted. But if the major military contractors take an interest in an emerging technology, as they have with MEMS, UWB, and GaN, it is a good bet that the technology will still be flourishing in 20 years.

Jack Browne

Publisher/Editor

Microwaves & RF

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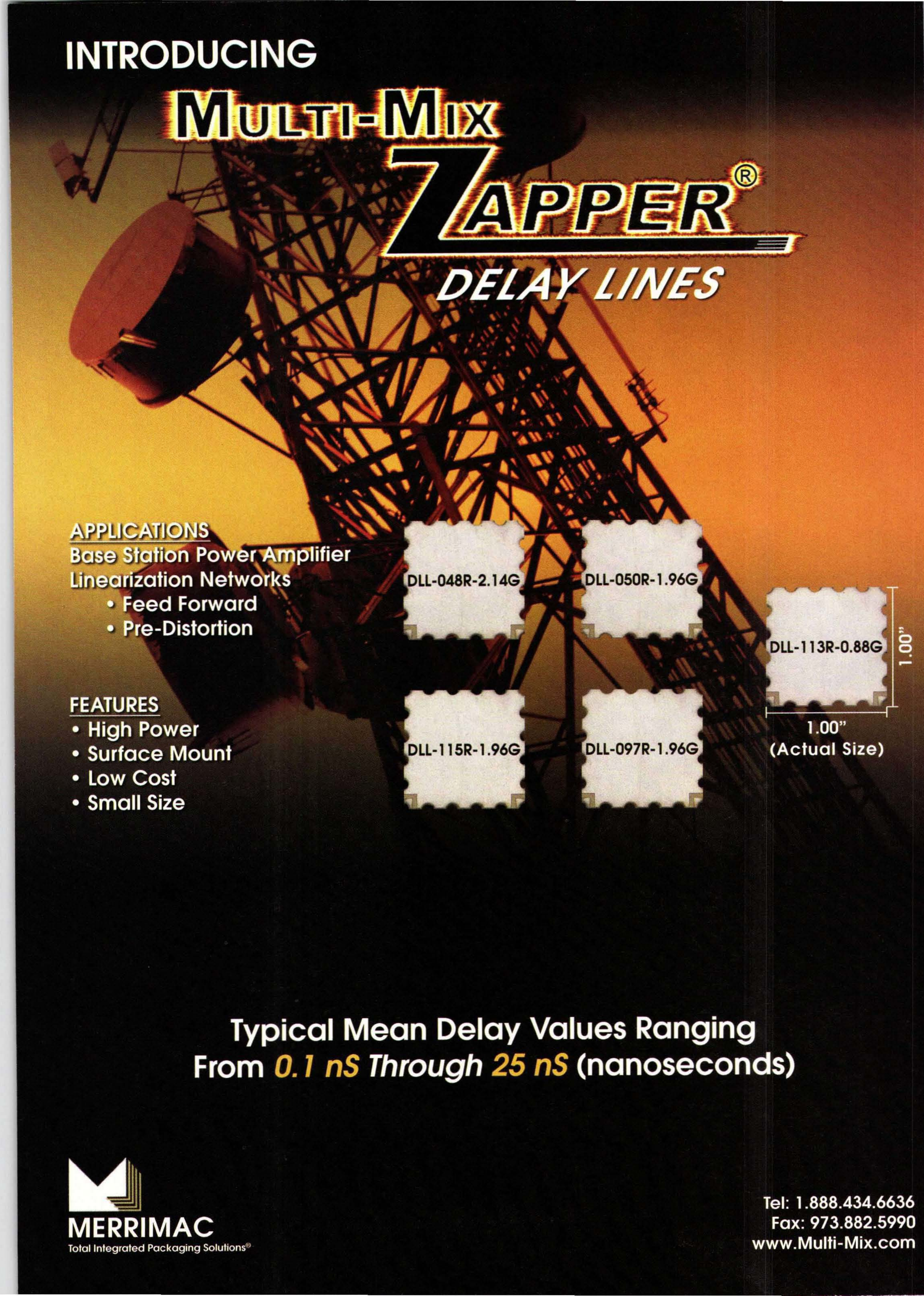
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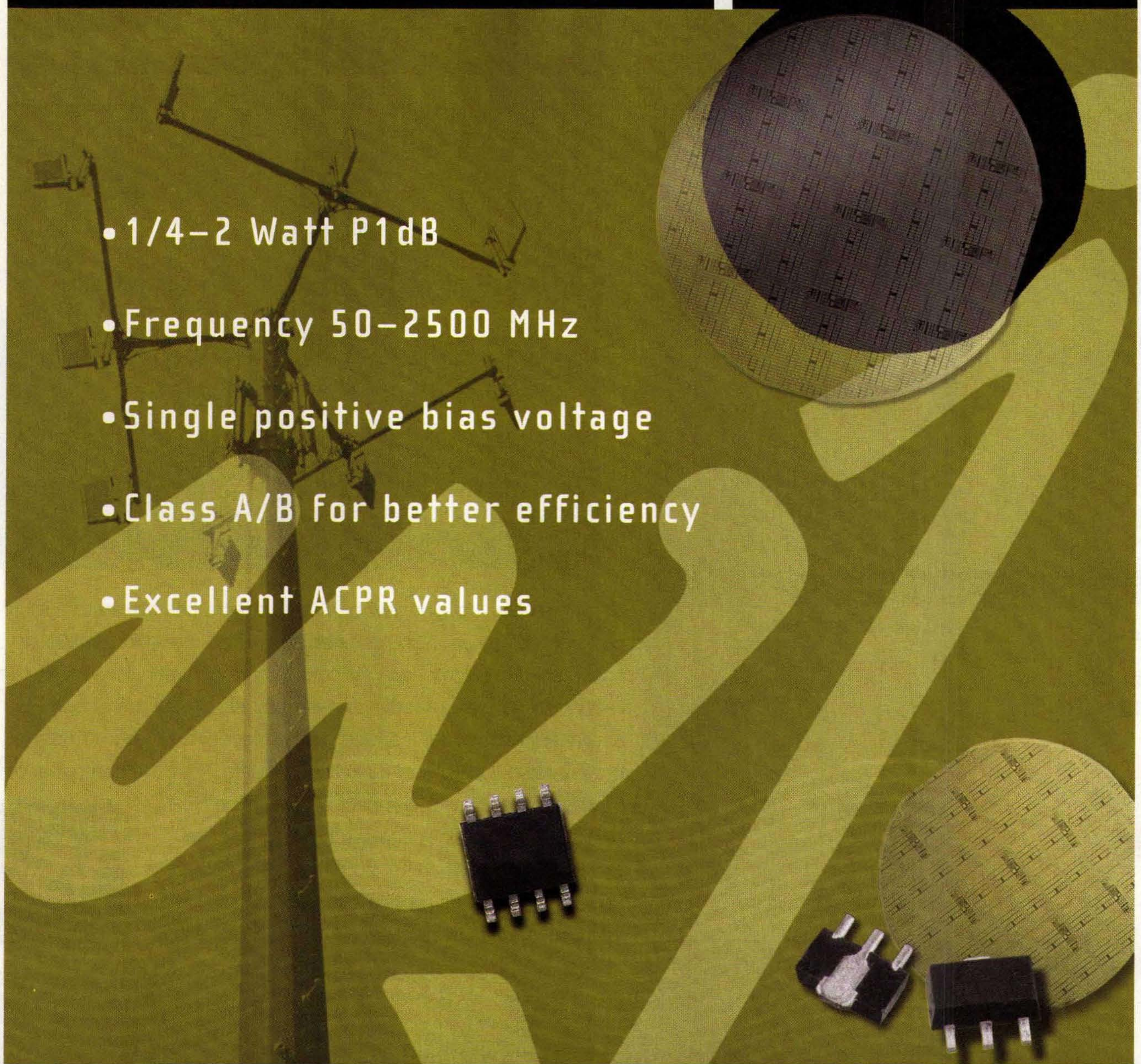

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Model Number	Frequency (MHz)	P1dB (dBm)	OIP3 (dBm)	Gain (dB)	Noise Figure (dB)	IS-95 Channel Power (ACPR)	Device Bias (V/mA)	Package Style
AH110	50-2000	+23	+39	20.5	5.0	13 (-45 dBc)	8/100	SOT-89
AH114	60-2500	+24	+41	19.0	5.0	17 (-45 dBc)	5/150	SOT-89
AH115	1800-2300	+28	+44	14.0	5.0	22.5 (-45 dBc)	5/250	SOIC-8
AH116	800-1000	+28	+42	17.0	7.0	23 (-45 dBc)	5/250	SOT-89
AH118	60-2500	+24	+41	20.5	4.0	17 (-45 dBc)	5/160	SOT-89
AH215	400-2300	+31	+46	17.0	7.0	25.5 (-45 dBc)	5/450	SOIC-8
AH312	400-2300	+33	+51	18.0	8.0	27 (-45 dBc)	5/800	SOIC-8

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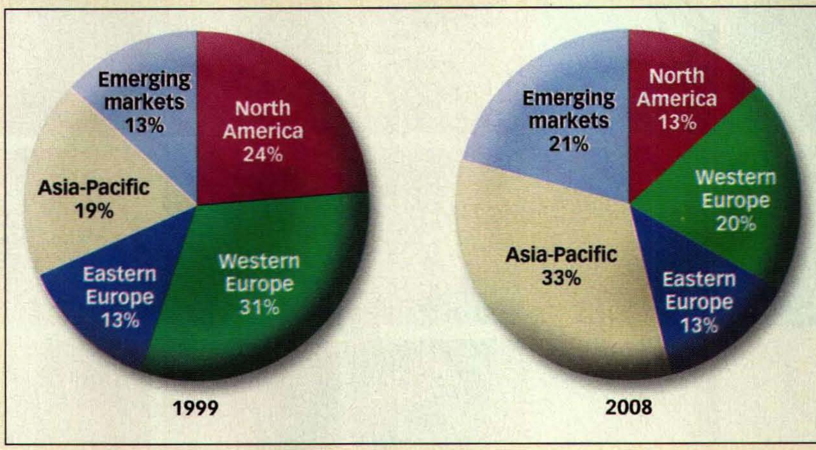
Worldwide OPGW Demand Shifts To Asia And Emerging Markets

PROVIDENCE, RI—Worldwide demand for optical ground wire (OPGW) remains strong and will grow by a two-percent compound annual growth rate (CAGR) from 2004 to 2008. However, much stronger growth rates and opportunities exist in the emerging markets. This is according to a report from KMI Research, *Worldwide OPGW Markets*.

The shift in regional share for OPGW deployments toward Asia, Africa, Middle East, and Latin America is shown in the **figure**. Asia and the developing countries will be driven by OPGW demand in China, which accounted for approximately 24 percent of worldwide OPGW demand in 2003. China's demand is influenced by major infrastructure projects in less-populated areas. As a developing nation, China has continued extensive deployments of optical fiber to upgrade its telecommunications infrastructure. China and other developing countries will account for 84 percent of OPGW deployments from 2004 to 2008.



Worldwide demand for OPGW peaked in 2000, when more than 60,000 kilometers were installed. Since 2000, annual demand has declined each year, but demand is still comparable to the levels at the outset of the telecom boom.

The demand forecast shows that Asia will be the largest regional market for OPGW. Asia accounted for 44 percent of OPGW demand in 2003, up from 19 percent in 1999, and will retain that share through 2008.

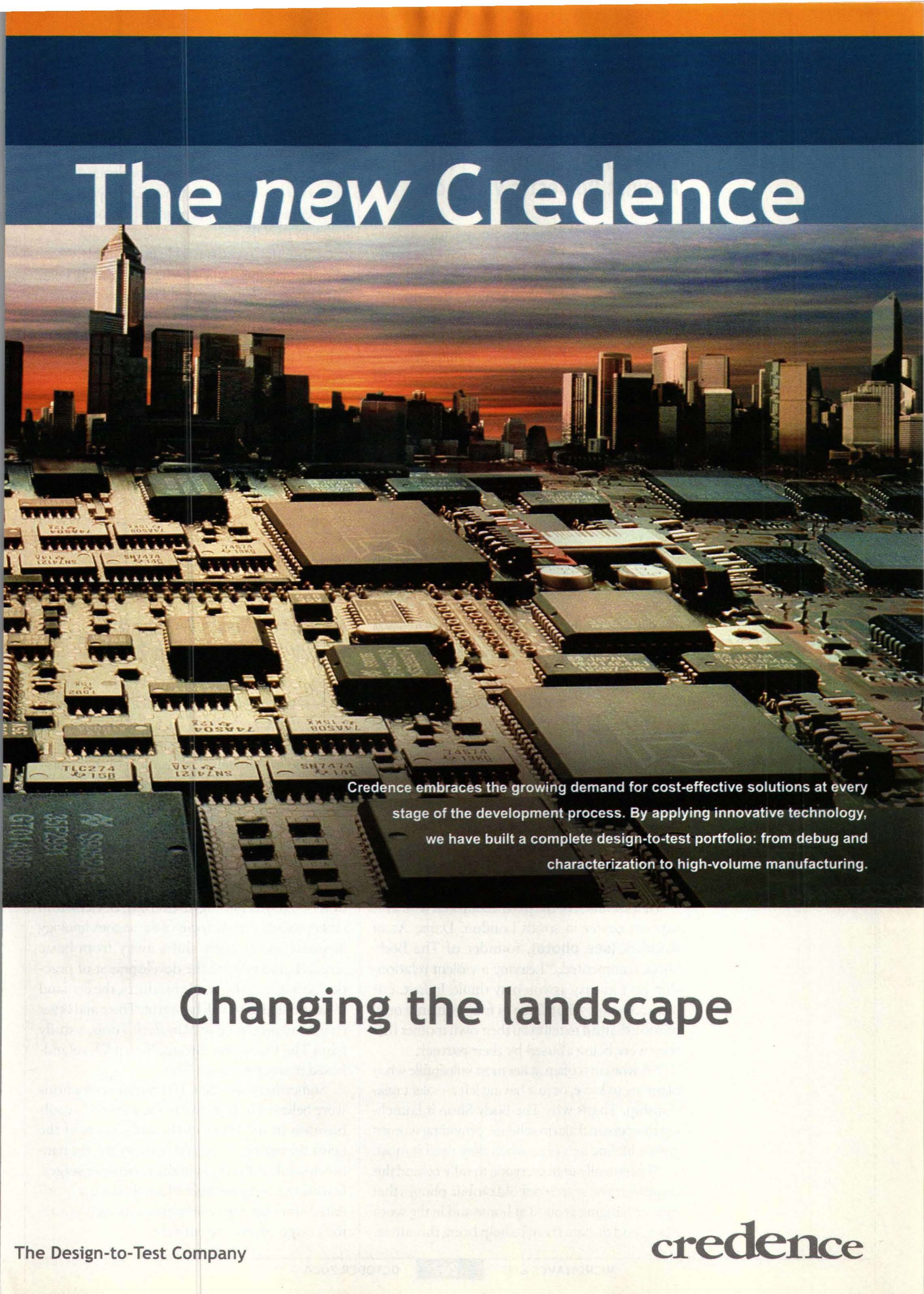
Will Freescale's Ultrawideband Technology Win The UWB Race?

OYSTER BAY, NY—On August 9, 2004, Freescale announced that their Direct Sequence Ultrawideband solution has received FCC certification. Subsequently, they also announced that module makers Global Sun Technology and Gem Tech Technology Co. would be building UWB systems around their chip-set solution.

How significant is this news? According to Alan Varghese, ABI Research's director of semiconductors research, "The FCC compliance is significant since regulatory issues can cause slowdowns in even exciting new technologies." Though UWB has been known for many years, it was only in February 2002 that the FCC was able to appease the concerns of incumbent spectrum users such as mobile-phone operators and the US military by allowing UWB's use in certain frequency bands provided that the signal stayed within certain energy levels.

With this certification, Freescale can begin commercial shipments of its chip set, and it enables Freescale's customers to design UWB technology into their consumer electronics applications; the first such equipment could be available by spring 2005. "At this point," says Varghese, "it looks like they have a lead of about a year on the rival MBOA-OFDM UWB standard."

A report from ABI Research, *Ultrawideband—Standards, Technology, OEM Strategy, and Markets*, analyzes the volumes and revenues from UWB electronics and chip sets, and the penetration of UWB technology across a variety of equipment and market segments.



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The Body Shop's Mobile-Phone Collection Aids In The Fight Against Domestic Violence

LONDON, ENGLAND—The Body Shop, in conjunction with the UK domestic-violence charity Women's Aid, have launched the "Donate a Phone, Save a Life" campaign. The initiative urges people across the UK to donate old or unwanted mobile phones. Some of these phones will be converted to become mobile personal alarms—with direct dial to emergency number 999 at the touch of any button—and distributed to at-risk women. Other phones will be recycled to raise money for the campaign. The campaign's organizers believe that there may be as many as 17 million unused mobile-phone handsets across the UK.

Dame Anita Roddick, founder of The Body Shop, launches the "Donate a Phone, Save a Life" campaign in partnership with the UK domestic-violence charity Women's Aid at a women's support center in south London.

The personal alarm scheme, the first of its kind in the UK for domestic-violence victims, will be rolled out initially in Birmingham, England and then in the English cities of London, Norwich, and Bristol as well as Glasgow, Scotland over the next six months. Postage-free envelopes to donate the handsets are available to pick up at over 300 outlets of The Body Shop across the UK.

At the launch of the partnership at a women's support center in south London, Dame Anita Roddick **(see photo)**, founder of The Body Shop, commented, "Leaving a violent relationship isn't as easy as you may think. In fact, our research shows that three in five women would be too ashamed to tell even their own mother that they were being abused by their partner.

"A woman is often at her most vulnerable when planning to leave, or just having left a violent relationship. That's why The Body Shop is launching this personal alarm scheme, providing women with a lifeline at a time when they need it most.

"I personally urge everyone to rally behind this campaign and search out old mobile phones that may be hanging around at home and in the work place, and donate them to help bring this amazing initiative to life."

Domestic-violence statistics are quite sobering. One in four women will experience domestic violence in their lifetime. Each week, two women are killed as a result of domestic violence in the UK.

Assistant Chief Constable Jim Gamble, Association of Chief Police Officers (ACPO) Lead for Domestic Violence and Harassment, states, "The police are concerned with holding perpetrators to account and protecting victims of this crime. I fully support the personal alarm scheme as it will aid victim protection by allowing them to have safer and more direct access to the police. I would encourage everyone with a spare mobile phone to donate it to The Body Shop. You can make a difference, you can help victims of domestic violence, and perhaps even save a life."

For further information on the "Donate a Phone, Save a Life" initiative, go to: www.womensaid.org.uk/campaigns&research/Bodyshop/Bodyshop_index.htm.

Nanotech Tools Demand To Reach $2.7 Billion In 2013

CLEVELAND, OH—The US market for nanotech tools is projected to increase nearly 30 percent per year through 2008 to $900 million, and then triple again to $2.7 billion in 2013. Nanotech tools represent a key segment of the emerging nanotechnology business, allowing for the visualization, measurement, manipulation, fabrication, production, simulation, and testing of matter in the nanoscale range—approximately 0.1 to 100 nanometers. Such tools are indispensable to the large scale commercial realization of nanotechnology materials, devices, and other products. As the focus of the nanotechnology business increasingly shifts away from basic research and toward the development of practical, commercially viable products, the demand for associated tools will be urgent. These and other trends are presented in *Nanotech Tools*, a study from The Freedonia Group, Inc., a Cleveland-based market-research firm.

Somewhat fewer than 100 private-sector firms were believed to be active in the nanotech-tools business in the US as of the early years of the new millennium. As would be expected, the nanotech-tools industry is in the formative stages, featuring a large number of small, research-oriented start-up-type companies, as well as various large corporate entities.

Hittite Microwave Expands To New Location In Chelmsford, MA

CHELMSFORD, MA—Hittite Microwave Corp. has relocated operations to a larger facility at 20 Alpha Rd. in Chelmsford. The new 72,000-sq.-ft. (6689-m) facility is more than double the size of the previous location, providing added manufacturing and design space including room for future expansion.

Over 31,000 sq. ft. (2880 m) is dedicated to engineering evaluation, quality/reliability, and production control/assembly/test, including a 6200-sq.-ft. (575-m) class 100K clean room. The large clean room accommodates new Class 100 work areas for MMIC die inspection/test as well as the expansion of Hittite's hybrid MIC module-assembly operations for space and military products. A new production test area provides ample room for additional test handlers, expanding Hittite's high-volume RF test capacity for plastic/ceramic packaged products. An environmental test lab provides screening and qualification for die, packaged die, and microwave modules/subassemblies.

More information about Hittite can be found at www.hittite.com.

"QUALCOMM is excited about the commercial release of GlobalTRACS Web 2.1."

QUALCOMM Announces Commercial Release Of GlobalTRACS Web 2.1 Solution

SAN DIEGO, CA—QUALCOMM, Inc. has announced the commercial release of the GlobalTRACS® Web 2.1 solution. Building upon the established success of the existing GlobalTRACS Web management application system, the newest version provides added functionality by allowing customers to track maintenance by machine. The system tracks an equipment's hours of operation, enabling customers to service their machines in a timely manner, thereby allowing companies to increase equipment productivity as well as reducing overall maintenance and administrative costs.

"QUALCOMM is excited about the commercial release of GlobalTRACS Web 2.1," says Tim Lewis, senior director of construction-equipment operations for QUALCOMM Wireless Business Solutions. "The system's added functionality enables our customers to take a more proactive approach to maintenance planning. Knowing when a machine is due for service helps our customers avoid over servicing or under servicing their equipment, providing them with significant cost savings."

Key enhancements include redesigned user interface screens, maintenance module and utilization summaries, cross-street proximity on demand and search capabilities, Mozilla browser support, and enhanced mapping features. The GlobalTRACS solution collects, manages, and transmits equipment operating status and location data, all easily accessible through the Web-based application or integrated into existing back-end business software systems.

Kudos

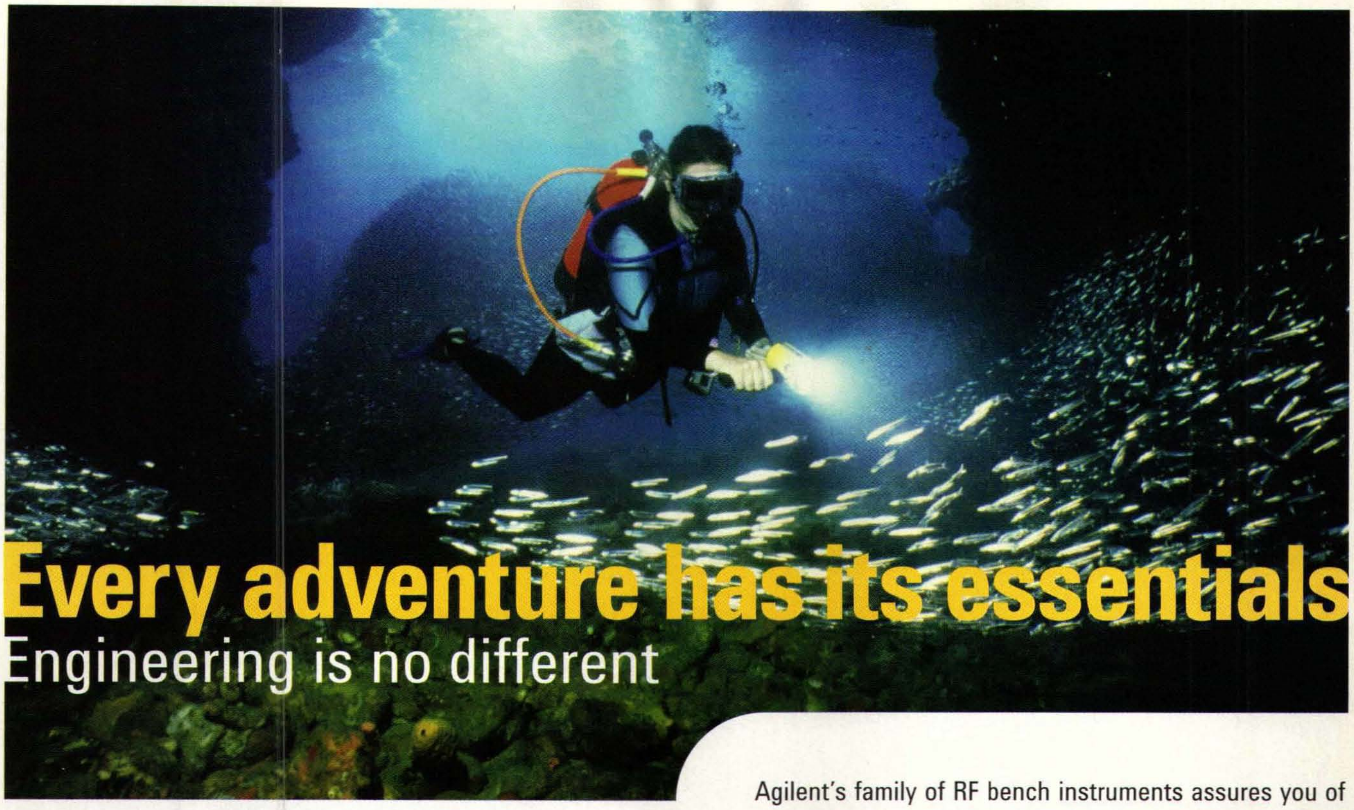
GREENSBORO, NC—RF Micro Devices, Inc. announced that Gartner Dataquest has recognized RFMD as the world's seventh-largest global wireless-communications semiconductor supplier, based on revenue. According to an August 2004 report entitled, "Market Share: Wireless Communications Semiconductors, Worldwide, 2003," Gartner Dataquest estimated that RFMD held approximately 3.9 percent of the $16.2 billion global market for wireless-communications semiconductors. The Gartner Dataquest report also concluded that RFMD is the number one provider of power amplifiers (PAs) for wireless handsets based on 2003 revenues.

CONCORD, NC—CT Communications has been added to the Deloitte Technology Fast 50 list, maintaining its spot as one of the fastest-growing companies in North Carolina for the fourth-consecutive year.

CTC was one of only five companies named to the Fast 50 list from the greater Charlotte region, and the only one from Cabarrus County. Each of the 50 fastest-growing North Carolina companies received the award based upon the percentage of revenue growth from 1999 to 2003.

TAMPA, FL—Tampa Microwave announced that the company has been certified to the latest ISO9001:2000 standard through International Management Systems (IMS).

CEDAR RAPIDS, IA—Rockwell Collins Government Systems has been recognized by the Center of Systems Management for achieving Level 5 maturity in accordance with the Software Engineering Institute's (SEI) Capability Maturity Model Integration (CMMI). MRF



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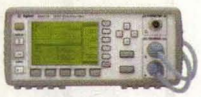
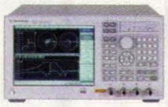
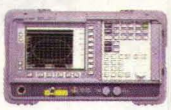

EPM-P power meters


ESA spectrum analyzers


ESG signal generators


ENA network analyzers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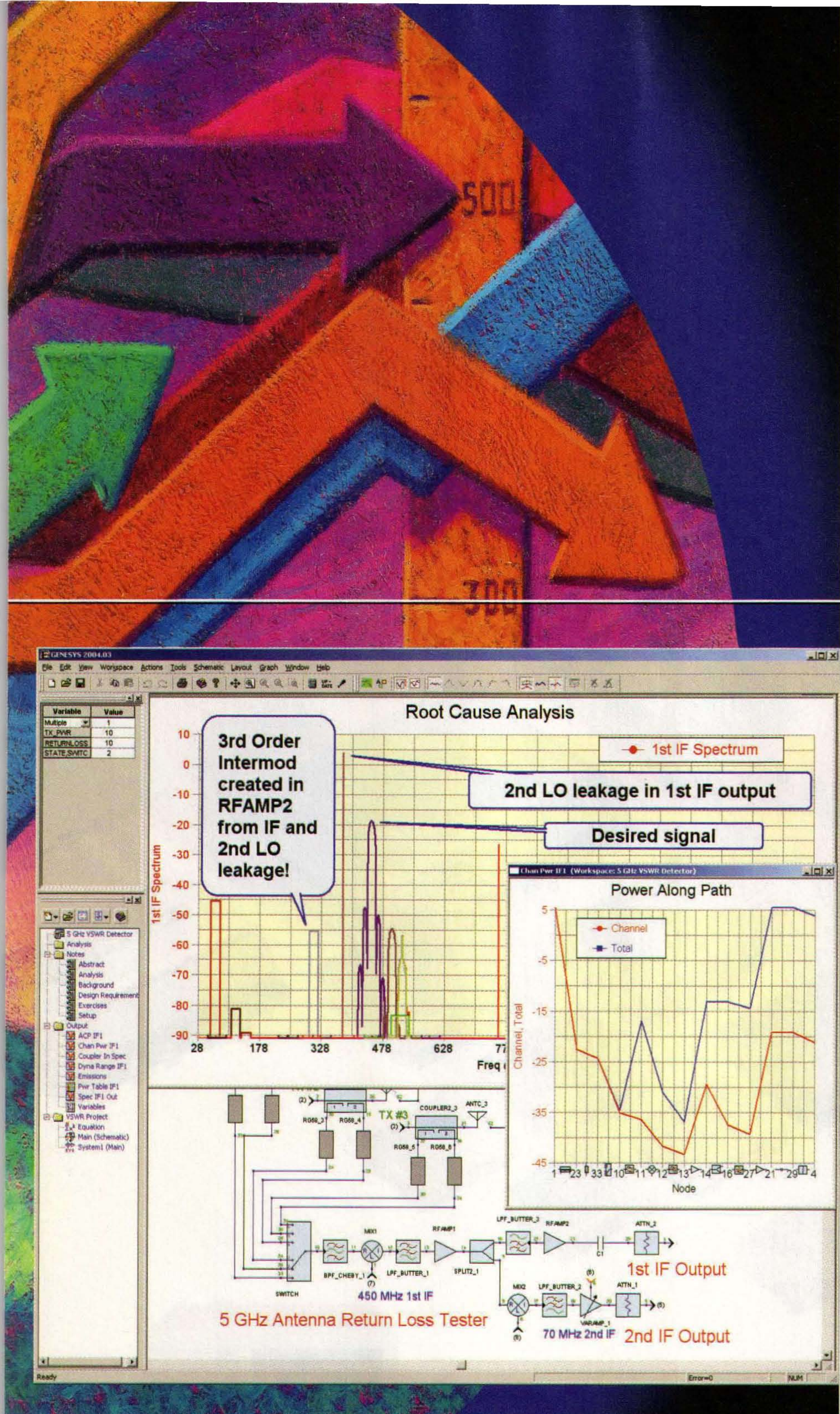
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1st IF Spectrum
2nd LO leakage in 1st IF output
Desired signal
Power Along Path
Channel
Total
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1st IF Output
70 MHz 2nd IF
2nd IF Output

NEWS

Emerging Technologies Benefit Creative Designers

Innovative (and courageous) microwave engineers can visualize the possibilities of newer technologies and translate these into practical high-frequency designs.

JACK BROWNE
Publisher/Editor

Emerging technologies often have a gradual but long-term effect on how high-frequency design engineers work. For example, when gallium-arsenide (GaAs) transistors and integrated circuits became commercially viable in the mid-1980s, amplifier designers shifted their focus from bipolar devices to the new semiconductors. In the current decade, several emerging technologies threaten to disturb the status quo for high-frequency designers, including microelectromechanical systems (MEMS) and ultrawideband (UWB) communications.

MEMS technology applies silicon semiconductor fabrication processes to the creation of mechanical devices, such as variable capacitors, electromechanical switches, optical lenses, and miniature motors. Early RF MEMS designs have focused on simple structures, including variable capacitors, microwave switches, and relays. Because packaging is critical to isolating MEMS devices from the operating environment, critics of initial MEMS devices cautioned that reliability would be a problem with these miniature components. But several companies have delivered reliable commercial products that counter these concerns.

RadantMEMS (www.radant-mems.com), for example, has developed the model RMSW100 single-pole, single-throw (SPST) switch for use from DC to 12 GHz, as well as the model RMSW200 SPST switch for use from DC to 40 GHz (the highest-frequency commercial MEMS switch currently available). The lower-frequency device has been performance tested at 10 GHz for high reliability at more than 100 billion switching cycles (see *Microwaves & RF*, July 2004, p. 102). It features less than 0.27 dB insertion loss and more than 25 dB isolation at 2 GHz.

Similarly, the model MICO6-CDK2 single-pole, double-throw (SPDT) switch from Dow-Key Microwave Corp. (www.dowkey.com) has been rated for 100 million switching cycles at frequencies from DC to 6 GHz. The high-isolation (45 dB isolation to 3 GHz and 40 dB isolation to 6 GHz) component minimizes insertion loss to 0.2 dB at 3 GHz and 0.5 dB at 6 GHz.

Of course, not all MEMS devices are switches. Discera (www.discera.com) has focused on the MEMS fabrication of microminiature oscillators. The company's first product, the model MRO 100, is the world's smallest multifrequency oscillator at one millimeter on a side (see *Microwaves & RF*, August 2003, p. 84). Supplied in wafer-level vacuum packaging, the 19.2-MHz oscillator is a miniature replacement for quartz-

crystal oscillators in low-power circuits, such as Bluetooth wireless devices and cellular telephones. The source draws 2.7 mA current from a +3-VDC supply.

For companies interested in exploring the boundaries of MEMS technology, MEMSCAP (www.memscap.com) features a wide range of standard MEMS devices, including high-Q inductors, variable capacitors, and RF switches. The firm also offers its customizable "Above-IC Technology," which allows the placement of RF MEMS devices directly on top of a silicon IC.

MEMS technology is also well suited for optical applications, such as movable mirrors for tunable lasers. MEMS Optical, Inc. (www.memsoptical.com), for example, is a leading supplier of refractive and diffractive microminiature optics and MEMS devices for optical applications. The company offers lines of standard devices such as scanning two-axis tilt mirrors and moving mirrors for tunable lasers as well as an array of optical MEMS foundry services.

With the aid of many well-known corporate sponsors, the Carnegie Mellon University Microelectromechanical Systems Laboratory (www.ece.cmu.edu) is pursing the design and development of MEMS devices using batch-fabrication processes, particularly IC fabrication processes. Jointly associated with the university's Department of Electrical and Computer Engineering and the School of Computer Science's Robotics Institute, as well as the school's Institute for Complex Engineering Systems the MEMS Lab is investigating nanometer-scale data storage, microsensors and microactuators, embedded microinstruments, microrobots, and modeling and design tools for simulating these devices. Industrial Affiliates include ADtranz, Benchmark Photonics, Coventor, DARPA, Intel Corp., the National Science Foundation, STMicroelectronics, and XACTIX. The MEMS Lab includes a 4000-sq.-ft. Class 100 clean room for fabrication, an advanced wafer-probe system for testing, and a long list of computer-aided-engineering (CAE) tools for modeling, including software from Ansoft, Cadence Design Systems, Coventor, and The MathWorks. Sandia Laboratories (www.sandia.com) offers a comprehensive lineup of MEMS fabrication, modeling, and testing services for those interested in creating their own MEMS devices.

Modeling a technology like MEMS poses a challenge for software developers since both electrical and mechanical characteristics must be represented. Coventor (www.coventor.com) offers one of the most widely used design tools with their CoventorWare software suite. The integrated set of tools offers a comprehensive methodology for the design, optimization, and analysis of microminiature devices, including MEMS and fluidic components and subsystems. Individual software engines handle schematic entry, two-dimensional layout, three-dimensional model generation, and model synthesis. The tools are available separately or bundled in any combination. The firm, which recently launched an updated version of its website, offers a free (30-day) software evaluation of the 3D analyzer EM3DS on its website.

Advances in MEMS technology will aid both commercial and military systems. Both commercial and military interests are also pursuing UWB technology for its elegance in handling high date rates at low power levels and sort distances. In essence, a UWB transmitter sends billions of pulses occupying a fairly wide bandwidth. The pulses are arranged according to a temporal sequence known to the receiver, which can then extract the voice, data, or video content carried by the pulse train.

Two years ago, the Federal Communications Commission (FCC) mandated the use of the spectrum from 3.1 to 10.6 GHz for UWB transmissions in the United States at a limited transmit power of –41 dBm/MHz. The FCC had grappled with concerns over UWB interference with existing applications, such as the Global Positioning System (GPS), C-and satellite communications, and the Microwave Landing System (MLS) before finally agreeing to the 7.5-GHz slice of bandwidth for UWB use.

In order for UWB technology to earn

widespread acceptance for applications such as short-range data and video transfer, a universal transmission standard must be adopted by product designers. So far, UWB supports have divided into two camps.

This past September, the MultiBand OFDM Alliance (MBOA) announced the formation of the MBOA Special Interest Group (MBOA-SIG) to support standard specifications for short-range UWB technology. MBOA-SIG promoter companies include Alereon, Hewlett Packard, Intel Corp., Nokia, Philips Electronics, Samsung Electronics (SAIT), Staccato Communications, Sony, Texas Instruments, and Wisair. According to UWB strategist at Intel and MBOA co-founder Stephen Wood, "Our membership of more than 170 companies includes the leading semiconductor, personal-computing, mobile-phone, and consumer-electronics companies." The organization (www.multibandofdm.org) has developed specifications based on orthogonal-frequency-division-multiplex (OFDM) UWB for a physical layer (PHY) and progress is being made on specifications for the UWB Media Access Control (MAC) protocol layer.

The MBOA MAC and PHY specifications, adopted by the WiMedia Alliance and the Wireless Universal Serial Bus (USB) Promoters Group, will serve as the common radio platform for those industry standards. The MBOA specifications are a basis for Wireless USB applications, adding wireless connectivity to the large installed base of USB products. The MBOA and WiMedia Alliance are also working closely with the IEEE 1394 Trade Association.

The UWB Forum (www.uwbforum.org), which was formed earlier this year, promotes the use of common signaling mode (CSM) and direct-sequence UWB (DS-UWB) approaches for product interoperability rather than frequency-hopped orthogonal frequency-division multiplex (OFDM) UWB. The group claims that DS-UWB is well understood with clearly defined emission limits compared to OFDM UWB, and is available now through the Xtreme-


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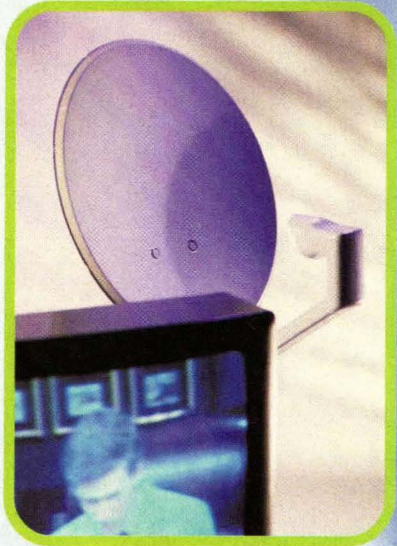

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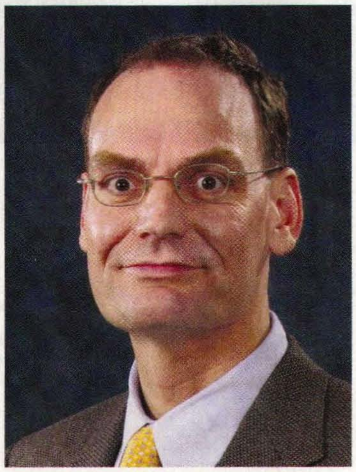
Spectrum™ chip sets. The CSM technique allows different classes of devices (e.g., MB-OFDM and DS-UWB) to communicate with each other in order to coordinate their actions and interoperate within the same wireless network.

The XtremeSpectrum technology was acquired by Motorola Semiconductor, now known as Freescale Semiconductor (a wholly owned subsidiary of Motorola) and one of the major supports of the DS-UWB format. The company announced during this past June's Wireless Connectivity (WiCon) World Expo in Amsterdam that it planned to deliver three advanced UWB product families, including the industry's first 1 Gb/s UWB solution. The first-generation XtremeSpectrum achieves data rates exceeding 110 Mb/s with DS-UWB technology. The planned next-generation product families will be engineered to deliver data-transfer rates of 220, 480, and 1000 Mb/s in peer-to-peer and ad hoc networking applications. The new product families will also be designed to integrate sophisticated power-management tools to help extend battery life, a critical requirement for mobile applications. According to Martin Rofheart, director of UWB Operations at Freescale (www.freescale.com), "It's clear that a variety of speeds—from 100 Mb/s up to 1 Gb/s—as well as a variety of power requirements and ranges are needed to serve the broad range of emerging handheld, mobile, and in-room video and audio applications."

The planned product families, which are to be designed to comply with the FCC's current Ultra-Wideband Report & Order, are scheduled to include driver support for multiple operating systems. The Freescale MAC chip is compliant with the IEEE 802.15.3 MAC protocol, while the Freescale PHY, which is based on the 802.15.3a DS-UWB proposal, provides data transfer rates ranging from 110 Mb/s to 1 Gb/s.

Additional emerging technologies include multilayer RF circuits and high-power wide-bandgaps devices, which are detailed in a longer version of this article available on the *Microwaves & RF* website at www.mwrf.com. MRF



Peter Walters is president and CEO of iTerra Communications (Palo Alto, CA). Before founding the company in 2000, he was vice president of engineering at Wavetronix. Iterra Communications designs and manufactures electronic components used in high-speed optical and wireless communication networks, instrumentation, and other systems in commercial, aerospace, and defense applications. The company's products include limiters, broadband amplifiers, data converters, timing management devices, logic devices, passive components, and high-speed logic evaluation and application boards. iTerra boasts design facilities in California, New York, and Italy. The firm offers the rare combination of expertise in digital, programmable logic, and microwave technologies, allowing it to exploit opportunities in a wide variety of broadband applications that usually are beyond the core competencies of a single company.

An Interview with iTerra's Peter Walters

MRF: *One of iTerra's key strengths appears to be expertise in microwave, digital, and optical technologies, and the ability integrate them. Was this your intention from the beginning?*

Walters: It was the combination that we wanted to have as early as possible, and it took us less than a year to achieve it, essentially by merging the expertise of three separate organizations with different core competencies into one cohesive unit to create more complete component solutions. We wanted to start with the best and this was where the talent was located.

MRF: *At first glance, it might appear that iTerra is concentrated on optical communications.*

Walters: You have to look a little closer. We have always addressed the optical-communications market from an electronics rather than optical perspective. We felt there was value in integrating the driver amplifier, which is a microwave or millimeter-wave circuit, along with some of the high-speed digital components that are required just before the driver, such as multiplexing and encoding. It's turning out to be really valuable in markets such as instruments, military applications, and even embedded systems. While our very first products were tailored to the optical-communications market, we've expanded into other areas, including microwave products such as microwave amplifiers in die and packaged form with high power over very broad bandwidths like 10 MHz to 22 GHz.

MRF: *You formed iTerra when electronics markets were weak and tumbling, yet you have not just survived but have grown. To what do you attribute your success?*

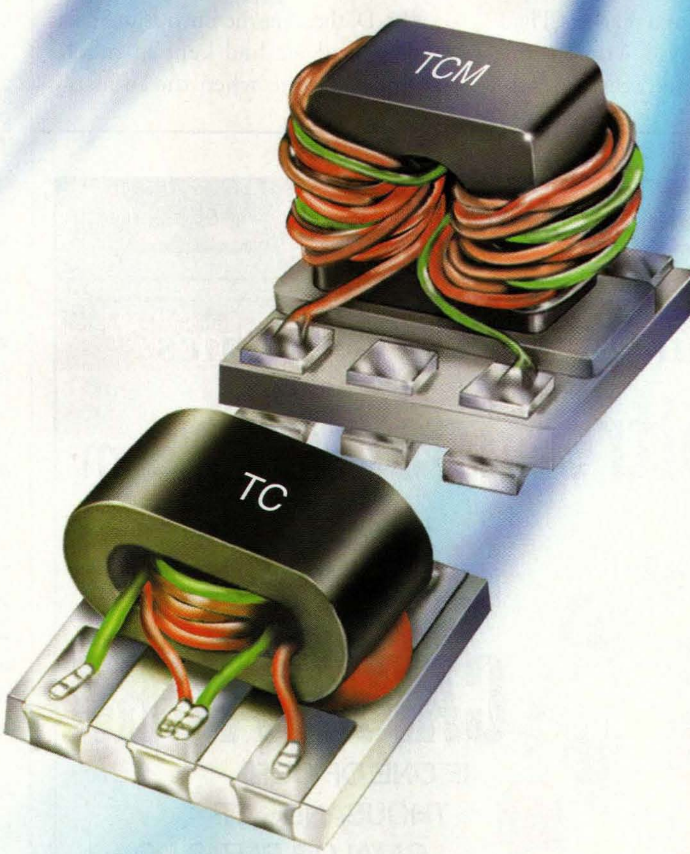
Walters: If you have confidence that the markets you have chosen to serve are likely to rebound within a reasonable time, you can use the interim period to establish customer relationships and optimize product development. You can also find more highly-qualified people, buy instruments and other equipment at very reasonable prices, and lease facilities at lower cost. However, you must be able to survive through this interim period. If you can, you'll often be very well positioned to address opportunities ahead of others in the market, which is where we believe iTerra is today.

MRF: *Might it be said that survival is often dependent on the willingness of the people or organizations providing the company's funding to tolerate an extended period before they see a meaningful return on their investment?*

Walters: We are extremely fortunate in this regard, because the individuals responsible for funding iTerra are very unusual in the way they view their investments. Their longer-term investment strategy makes them unique (www.stellartllc.com) compared to more typical VC based "public" investment dollars that require quicker ROIs and by definition puts people in second place. The payoff is to be able to create a stable company with longer term potential and higher overall value. This doesn't mean we are not pushing hard to grow, we are already through break-even and have more than three dozen customers for whom we are delivering products, including very large commercial manufacturers and military prime contractors.

MRF: *How did iTerra actually come to be?*

RF TRANSFORMERS



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TC1-15	1C	800-1500	800-1500	1.29
TC1.5-1	1.5D	.5-2200	2-1100	1.59
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TC3-1T	3A	5-300	5-300	1.29
TC4-1T	4A	.5-300	1.5-100	1.19
TC4-1W	4A	3-800	10-100	1.19
TC4-14	4A	200-1400	800-1100	1.29
TC8-1	8A	2-500	10-100	1.19
TC9-1	9A	2-200	5-40	1.29
TC16-1T	16A	20-300	50-150	1.59
TC4-11	50/12.5D	2-1100	5-700	1.59
TC9-1-75	75/8D	0.3-475	0.9-370	1.59

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TCML1-11	1G	600-1100	700-1000	1.09
TCML1-19	1G	800-1900	900-1400	1.09
TCM2-1T	2A	3-300	3-300	1.09
TCM3-1T	3A	2-500	5-300	1.09
TTCM4-4	4B	0.5-400	5-100	1.29
TCM4-1W	4A	3-800	10-100	.99
TCM4-6T	4A	1.5-600	3-350	1.19
TCM4-14	4A	200-1400	800-1000	1.09
TCM4-19	4H	10-1900	30-700	1.09
TCM4-25	4H	500-2500	750-1200	1.09
TCM8-1	8A	2-500	10-100	.99
TCM9-1	9A	2-280	5-100	1.19

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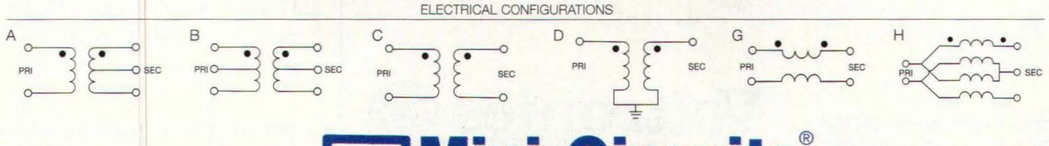

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Walters: I was at Hewlett-Packard Co. and stayed with Agilent after its creation in a position that allowed me to gain a pretty good perspective about a lot of different technologies and markets. I had gotten to know David Arnold, the founder of Wavetronix, who I greatly respected, and his company offered me the opportunity to become an equal partner. Earlier I had gotten to know Andrea Berri-Berruto while working on a Ph.D. thesis at the European Space Agency, and we had kept in touch. Around the time when the industry prophets were projecting huge potential for 40 Gb/s optical communication—while at Wavetronix—he told me, after he left his company, he had developed some very interesting amplifier technologies for the optical market, and suggested we consider creating a company to build them, among other things. The idea grew, and iTerra was spun out from Wavetronix.

MRF: *Of course, the 40 Gb/s market never materialized, so how did you cope with this?*

Walters: Well we were certainly as surprised as anyone to see just how fast and how far the fiber-optic market would collapse. We quickly shifted to developing products for 10-Gb/s applications because this market seemed likely to produce meaningful revenue much sooner, which it is now doing. We also began to expand our line of high-speed digital ICs and microwave and millimeter-wave power devices, and began to exploit our multi-technology capabilities to produce custom products.

MRF: *You have mentioned the quality of your multidisciplined engineering team. How have you pulled such talent together?*

Walters: We firmly believe you must create what we call a learning environment in which creativity and reaching out to embrace new opportunities are rewarded, and failures aren't career-ending, cataclysmic events. This isn't something we take lightly because I've seen what happens when innovation is discouraged, and it isn't conductive to success. People at iTerra are encouraged and given the tools to take risks that may ultimately result in successful products or penetration of new markets. And we don't just pay lip service to the idea of employees benefiting from what they do. We make sure those benefits are tangible. You might say we are in the business of making people successful, both our customers and iTerra.

MRF: *Can you tell me about some of the results that this amalgamation of talent has delivered?*

Walters: The products we have introduced show just how strong our engineering capabilities are. For example, we have just introduced two broadband amplifiers, one in chip form and the other packaged, that are the equal of anything currently available. The iT2007, which is the unpackaged die, delivers up to 1 W, with a bandwidth of 10 MHz to 22 GHz, and delivers power-added efficiency greater than 12 percent to 12 GHz, and 10 percent to 18 GHz. Its efficiency and the fact that it consumes half the power of its closest competitor are big advantages when you're building higher-power amplifiers that use multiple devices.

We are also the first company to introduce a 12.5-Gb/s digital phase delay which has unique benefits over conventional designs, and the first to deliver an NRZ-to-RZ converter that integrates the driver and digital electronics in a small, surface-mount package. It has truly exceptional performance up to 12.5 Gb/s. We are also the first to deliver a converter for duobinary modulation, and we are creating custom products that combine high-speed digital and microwave circuits based on customer requests.

MRF: *Do you see your business model as the way of the future for microwave companies?*

Walters: Ours is typical of what is required to be successful going forward in a marketplace that is radically different than in the past. The model needs to include both new core value generation and maximum product leverage for value. That's not to say the traditional approaches to microwave design won't be viable in the future for some companies, especially those doing military work. However, commercial and even some military opportunities require a new approach that is more typical of the digital world. Basically, you have to structure your efforts as a company for a balanced and dynamic alignment in three key areas: market, technology, and economics. Take technology as an example. The speed at which new technology is available creates a "technology leveling" factor for everyone in the business. If you can't respond quickly you can't maintain your position.

MRF: *Is military work of interest to iTerra?*

Walters: It's a prime focus, because there is a great need for integration of traditionally diverse technologies in military systems. We are already addressing this with some Tier One DoD contractors, and can screen our products for hi-rel and spaceflight applications.

MRF: *Where do you see iTerra in five years?*

Walters: iTerra will always be a people-first company that creates an environment for success driven by creative solutions. Let's wait and see what this drives to in the future. The track record to date looks pretty exciting. MRF

Four-Port Network Analyzers Reach 20 GHz

COMBINING SPEED WITH high measurement accuracy, model R3860A is a four-receiver, four-port vector network analyzer with wide frequency range of 300 kHz to 20 GHz. With sweep speed of 5 µs/point (as much as eight times that of competitive analyzers), the instrument's receiver-per-port design eliminates complex matrix switching and simplifies the testing of RF hybrid modules and multifunction, multiport modules used in both commercial and military systems. The analyzer achieves a dynamic range of typically 125 dB at 8 GHz with the aid of high-speed math processing and proprietary analog technology. P&A: $38,800 and up; 6 wks.

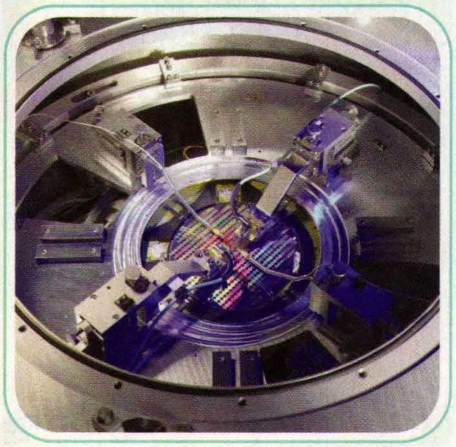
Advantest America Measuring Solutions, Inc., 258 Fernwood Ave., Edison, NJ 08837; (866) 414-0870 or MetricTest in Hayward, CA; (800) 417-4370, Internet: www.metrictest.com/advantest.

Vacuum Probe Systems Test RF MEMS

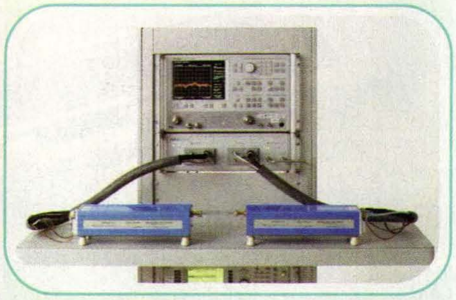
MICROELECTROMECHANICAL SYSTEMS (MEMS) devices are essentially mechanical structures, such as switches and relays, fabricated by means of semiconductor processes. Since they are designed to operate in vacuum environments, testing RF MEMS devices has represented a challenge for conventional measurement systems. Fortunately, a family of vacuum probing stations has been developed for testing MEMS devices under real-life conditions. By modifying the reliable SUSS PAV150 probe platform into a custom-made RF MEMS test system, the semiautomatic wafer probe system can test up to 200 mm wafers in a vacuum environment up to 10-7 mbar. The system's probes and calibration substrates provide stable performance over a wide temperature range 10 to 393 K with temperature uniformity of ±0.8 K and a stability of ±0.5 K.

SUSS MicroTec, Inc., 228 Suss Dr., Waterbury Center, VT 05677; (800) 685-7877, (802) 244-5181, FAX: (802) 244-5103, Internet: www.suss.com.

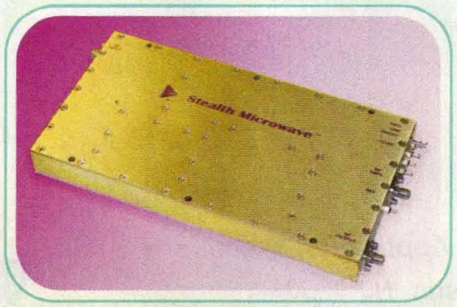
ADVANTEST'S MODEL R3860A VNA



SUSS MICROTEC'S PROBE SYSTEM



ANRITSU'S MODEL ME7808B VNA



STEALTH MICROWAVE'S SOLID-STATE AMPLIFIER MODEL SM2025-44L

Analyzer Aims At Broadband Testing

DEVELOPED FOR broadband testing, the model ME7808B vector network analyzer (VNA) provides continuous frequency coverage from 40 MHz to 110 GHz, and can also be configured with any of the company's Lightning line of VNAs for banded coverage over the 50-to-325-GHz range. The analyzer is equipped with the company's W1 Connector' coaxial interface for continuous coverage to 110 GHz. The analyzer's system dynamic range is 97 dB at 20 GHz and 79 dB at 100 GHz. If the ME7808B is configured with an extended W band waveguide test port for millimeter-wave measurements, system dynamic range is 90 dB at 75 GHz and 87 dB at 100 GHz. P&A: $183,000 and up; 6 to 8 wks.

Anritsu Co., 490 Jarvis Dr., Morgan Hill, CA 95037-2809; (800) ANRITSU (267-4878), (408) 778-2000, FAX: (408) 776-1744, Internet: www.us.anritsu.com.

Linear Amplifier Delivers 25 W For 3G

SOLID-STATE AMPLIFIER model SM2025-44L is based on GaAs FET technology and high-performance linearization circuitry. The linear amplifier, which is well suited for UMTS and 3G cellular applications, delivers +44 dBm output power (25 W) at 1-dB compression from 2.0 to 2.5 GHz. It achieves a typical output third-order intercept point of +62 dBm over the full 500-MHz band. It includes forward/reverse power detection, and high-speed switching of RF output at speeds to 10 µs. Available in rack-mount or modular form, the linear GaAs FET amplifier can also be supplied with an integral heatsink. The modular version measures 7.5 × 3.97 × 0.79 in. with female SMA connectors.

Stealth Microwave, Inc., 1007 Whitehead Rd. Ext., Trenton, NJ 08638; (888) 772-7791, (609) 538-8586, FAX: (609) 538-8587, e-mail: sales@stealthmicrowave.com, Internet: www.stealthmicrowave.com.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Growth For China Navigation Market?

WITH ONLY TWO MODELS of automobile offering in-vehicle navigation systems in China, this industry is in its infancy. But the growth potential for navigation technologies in this large country cannot be ignored.

Several barriers impede development of an in-vehicle navigation market, according to ABI Research analyst Junmei He. ABI have released a study, *The Chinese Market for In-Vehicle Navigation Systems*, which examines this market in its formative stages.

Little of China has been digitally mapped, mainly due to strict government control over map source data. Only 20 cities are covered by both models of automobile with in-vehicle navigation systems to date, and only three companies are authorized to make and sell digital maps.

According to He, "China is undergoing a massive upgrade to its infrastructure and road network. This rapid rate of change means that expensive map updates will be needed frequently."

Most GPS-based navigation systems are imported, but chip sets and components are also imported by Chinese vendors who assemble them into semi-domestic products. Imported systems cost \$1200 to\$1800 (another inhibitor) while locally assembled units sell for two-thirds less.

Politics raises its head, too. The government, fearing dependence on the US-developed GPS satellite constellation, is promoting solutions based on China's own Beidou satellite, though in the near future Beidou will serve only industrial clients rather than individual clients.

Standards for maps and equipment are also lacking. But the government recently assembled a team to establish satellite-navigation application standards, a task estimated to take three years.

That has not stopped Toyota Tsusho Corp. from entering a joint venture with the Beijing Siwei Tuxin Navigation Information Technology Corp. to produce and sell digital maps in China.

China's burgeoning auto industry will provide in-vehicle navigation's best support. The large volumes it will deliver should see wider adoption and significant price reductions by 2009. MRF

CONTRACTS

Rockwell Collins—Along with AAI and Whitney, Bradley, & Brown (WBB), Rockwell Collins was awarded a contract from the US Army Aviation Applied Technology Directorate (AATD) for the Manned/Unmanned Common Architecture Program Phase III (MCAP III).

EMS Technologies, Inc.—Announced that it has been selected by Honeywell and Thales Avionics as the supplier of high-speed data satellite-communications products for their new HS-720 high-speed data system.

Under the terms of a seven-year agreement signed last week, EMS will develop custom avionics products, which will complement the Honeywell/Thales MCS-4000/7000 satellite-communications systems. Over the next five years, the forecasted value of this agreement is over $50 million. These avionics products include high-power amplifiers and high-speed data units. These products will support Inmarsat Swift64 and will be upgradeable to SwiftBroadband, which is expected to be available in 2006. SwiftBroadband will provide 432 kb/s per channel.

Endwave Corp.—Has executed a development agreement with a major US defense contractor to develop RF Distribution and Test Modules for an airborne defense system. The initial $800,000 development contract is deliverable through the first quarter of 2005, leading to subsequent initial production. Design engineering will take place in Endwave's Sunnyvale, CA headquarters, with production slated for their Manufacturing Center of Excellence in Diamond Springs, CA.

Lucent Technologies—Announced a new contract with Guangdong Unicom valued at $98.5 million for its phase III CDMA network-expansion project. Under the terms of the contract, Lucent will supply its CDMA2000 solutions and will provide services support. The new network is expected to improve the capacity and coverage in eight cities in China's Guangdong Province: Guangzhou, Foshan, Zhongshan, Zhuhai, Zhanjiang, Maoming, and Yangjiang.

With this expansion, Guangdong Unicom will be able to offer new revenue-generating services such as video-on-demand, live streaming video, and high-speed mobile Internet access to its subscribers.

Boeing—A Boeing-led team has been awarded a 15-month, $54.6 million contract by the US Air Force to develop system architectures and initial designs for the next iteration of Joint Tactical Radio System (JTRS) software-defined radios.

FRESH STARTS

Hittite Microwave Corp.—Announced the appointment of a new sales-representative firm to serve customers in Southern California. ACETEC specializes in RF/Microwave sales to the consumer, industrial, military, and space-electronics industries. Their offices in San Diego, Tustin, and Santa Barbara offer full support to customers in the Southern California area.

To contact ACETEC, call (858) 784-0900, fax (858) 784-0909, e-mail sales@acetec.com, or see their website at www.acetec.com.

Sirenza Microdevices—Announced that it has shipped over 50 million silicon-germanium (SiGe) products since the initial introduction of its broad-based, high-performance RF integrated-circuit (RF IC) product line.

XMA Corp. and East Coast Microwave—Have signed a distribution agreement. Under terms of the agreement, East Coast Microwave will distribute XMA's full line of standard RF/microwave components including terminations, attenuators, and other passive products.

Computer Simulation Technology (CST)—Announced the appointment of Midwin and Olifson as product representatives in Southern California.

ANADIGICS, Inc.—Will be shipping production volumes of its AWT6108 7 × 10-mm indium-gallium-phosphide heterojunction-bipolar-transistor (InGaP HBT) GSM/GPRS power amplifiers (PAs) to Beijing Capitel Co. Ltd., a handset manufacturer in China.

RF Micro Devices, Inc.—Announced that Air2U, a Taiwanese designer and manufacturer of wireless consumer electronics products, is using RFMD's SiW3000 Ultimate Blue™ single-chip Bluetooth® component in the USB adapter. The adapter has been certified by Microsoft as an authorized device for testing the compatibility of Bluetooth wireless products operating with the Windows® XP system.

TriQuint Semiconductor, Inc.—Opened its Shanghai, China Sales and Applications Center: TriQuint (Shanghai) Trading Co. Ltd. This full-service center will provide support to TriQuint customers in mainland China and Hong Kong. functions available through the Shanghai office includes sales, customer service, technical support, and field-applications engineering for all TriQuint products.

Trompeter—Announced that effective September 1, 2004, Electronic Marketing Associates, Inc. (EMA) will have expanded representation into the Carolinas with the completion of EMA's buyout of rep firm CPF Atlantic. A veteran of more than 30 years in the industry, EMA has been representing Trompeter in the states of Alabama, Mississippi, Georgia, and Tennessee.

RF Industries, Inc.—Has acquired, for cash, Aviel Electronics, a privately held Las Vegas, NV-based manufacturer and marketer of microwave and RF connectors. Terms of the acquisition were not disclosed.

Aeroflex, Inc.—Announced that it has signed an agreement allowing Motorola, Inc. to market and distribute Aeroflex's line of advanced wireless test solutions in the US and Canada. The products sold through Motorola sales channels include Aeroflex's latest line of radio test systems, spectrum analyzers, power meters, signal generators, and microwave test equipment. MRF

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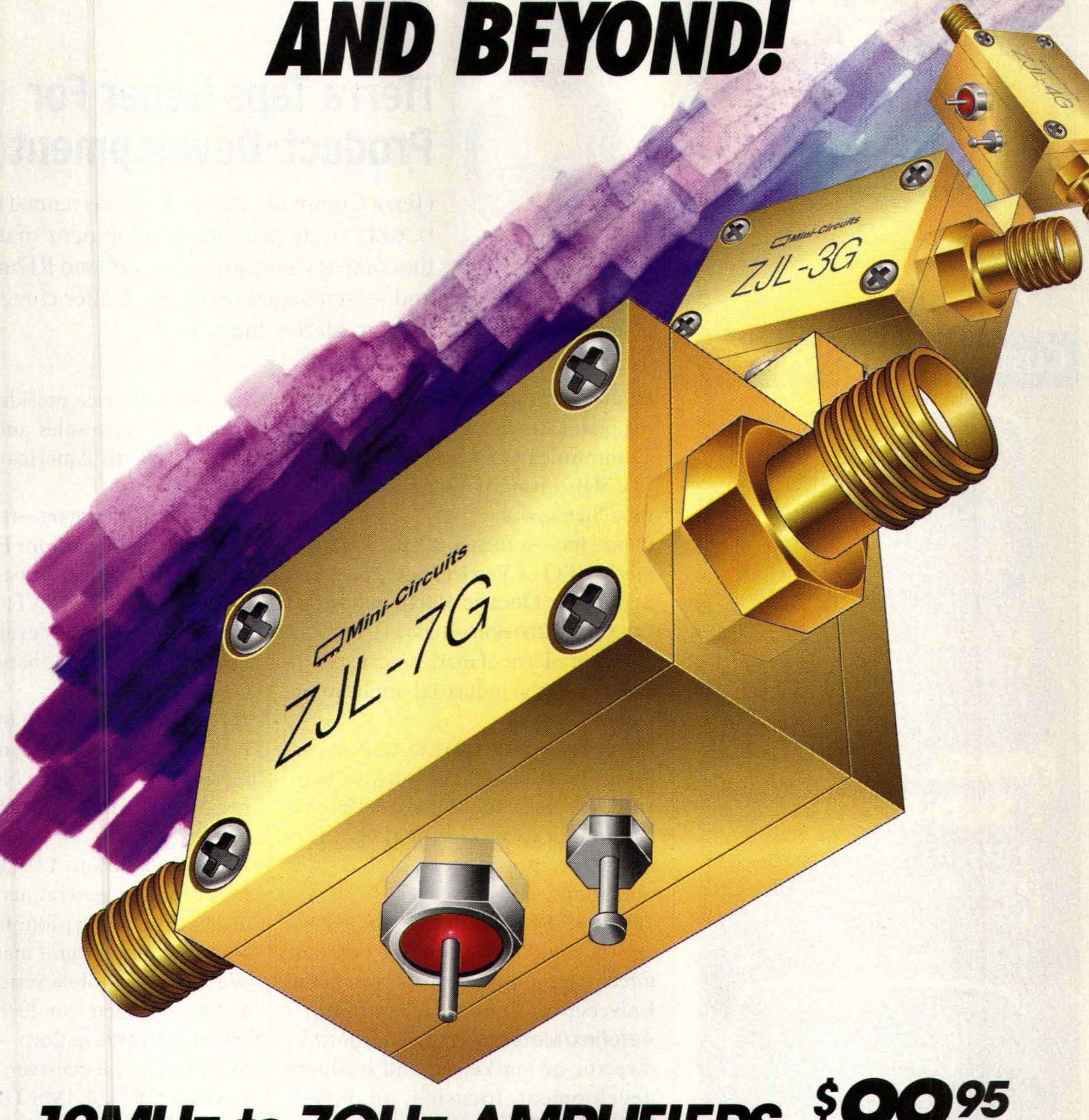

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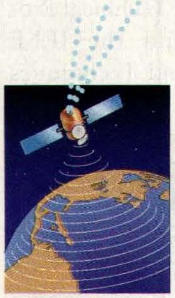

From amateur radio to cellular to satellite applications, with medium output power up to 17dBm, Mini-Circuits versatile ZJL and ZKL connectorized amplifiers offer the broad range of choices designers demand for achieving high system performance goals. Ultra-wideband models deliver **gain ranging from 9 to 40dB** and IP3 up to +32dBm. But beyond the performance and reliability built into these miniature 12V amplifiers lies another important feature, the low price...from only $99.95! Call now for fast delivery.

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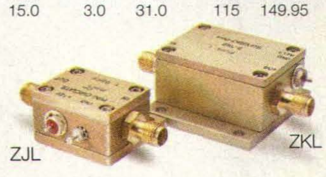
SPECIFICATIONS

Model	Freq (MHz)	Gain (typ) Midband (dB)	Gain (typ) Flat (±dB)	Max. P_{out}[1] (dBm)	Dynamic Range (Typ @2GHz[2]) NF(dB)	Dynamic Range (Typ @2GHz[2]) IP3(dBm)	I(mA)[3]	Price $ea. (1-9)
ZJL-5G	20-5000	9.0	±0.55	15.0	8.5	32.0	80	129.95
ZJL-7G	20-7000	10.0	±1.0	8.0	5.0	24.0	50	99.95
ZJL-4G	20-4000	12.4	±0.25	13.5	5.5	30.5	75	129.95
ZJL-6G	20-6000	13.0	±1.6	9.0	4.5	24.0	50	114.95
ZJL-4HG	20-4000	17.0	±1.5	15.0	4.5	30.5	75	129.95
ZJL-3G	20-3000	19.0	±2.2	8.0	3.8	22.0	45	114.95
ZKL-2R7	10-2700	24.0	±0.7	13.0	5.0	30.0	120	149.95
ZKL-2R5	10-2500	30.0	±1.5	15.0	5.0	31.0	120	149.95
ZKL-2	10-2000	33.5	±1.0	15.0	4.0	31.0	120	149.95
ZKL-1R5	10-1500	40.0	±1.2	15.0	3.0	31.0	115	149.95

NOTES:
1. Typical at 1dB compression.
2. ZKL dynamic range specified at 1GHz.
3. All units at 12V DC.



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GELLER

iTerra Taps Geller For Product-Development Spot

iTerra Communications, LLC has named BERNARD D. GELLER as product-development manager for the company's integrated broadband RF/microwave and mixed-signal products. Geller comes to iTerra from Herley Industries.

NEC America, Inc.—DWAYNE SAWYER to regional sales manager for the Radio Communications Systems Division (RCSD); formerly owner/director of Blue Buzzsaw, Inc.

iVoice, Inc.—ARIE SEIDLER to COO; formerly CEO of Vertical Solutions, Inc.

Schneider Electric North American Operating Division—TOM INSPRUCKER to vice president of marketing; formerly director of the industrial-applications team.

Motorola, Inc.—CHERYLYN CHIN to corporate vice president of software market development for Motorola's Personal Communications Sector (PCS); formerly vice president of global sales operations.

Tahoe RF Semiconductor, Inc.—PROFESSOR LARRY LARSON to the board of directors; continues as professor at the University of California, San Diego.

Aeroflex/Metelics—PETER SAHJANI to director of marketing and business development focusing on InGaP HBT/pHEMT amplifier products for the wireless infrastructure telecom market; formerly employed at EiC Corp. In addition, CHRISTOPHER ZIELKE to director of business development for its COTS *Plus* products and multichip semiconductor module marketing and services development; formerly director of engineering at Avnet MTS.

Xpedion Design Systems—JAMES HOGAN to the board of directors; remains as general partner at Telos Venture Partners.

Plexus Corp.—RALF BÖER to the board of directors; continues as chairman and CEO of the law firm Foley & Lardner LLP.

Alcatel—TOM EGGEMEIER to vice president and general manager of Alcatel's enterprise voice business in North America; formerly vice president of North American voice sales and vice president of North American enterprise channels.

EMS Satellite Networks—PENNY GLOVER to managing director for Europe, Middle East, and Africa; formerly employed at SES-ASTRA and SATLYNX in key roles supporting the development and deployment of broadband DVB-RCS services.

TeraVicta Technologies, Inc.—KENNEY R. ROBERTS to president and CEO; formerly COO at Layer N Networks and president and CEO of Colorado MicroDisplay.

Xilinx, Inc.—OMID TAHERNIA to vice president and general manager of the dedicated DSP division; formerly vice president and general manager of the Wireless and Mobile Systems Division at Motorola Semiconductor.

Maury Microwave Corp.—JOHN SEVIC to ATS technical manager; continues to serve on the IEEE IMS Technical Program Committee and the IEEE Microwave Theory and Techniques Review Board.

SEVIC

LEE

Park Electrochemical Corp.—FREDDY LEE to Asia Pacific director of product sales; formerly director of advanced product marketing for the Asia Pacific region. MRF

▸SHORT COURSES

Managing and Testing SONET Performance for Metro Access
November 3-5 (Madison, WI)
College of Engineering, University of Wisconsin—Madison
(800) 462-0876
Internet:
www.epdweb.engr.wisc.edu/webG546

Future Ultra-Wideband Systems
November 4-5 (Washington, DC)
November 8-9 (San Diego, CA)
November 15-16 (Orlando, FL)
December 2-3 (Las Vegas, NV)
(310) 563-1223, FAX: (310) 563-1220
e-mail: ttchq@ttcus.com
Internet: www.technologytraining.com

Streamlining the Product Development Process
November 8-9 (Pasadena, CA)
California Institute of Technology
(626) 395-4045, FAX: (626) 795-7174
e-mail: execedu@caltech.edu
Internet: www.irc.caltech.edu

R.A. Wood Short Courses
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November 8-9 (Philadelphia, PA)
Introductory RF and Microwaves
November 8-9 (Philadelphia, PA)
RF and Microwave Receiver Design
November 10-12 (Philadelphia, PA)
Wireless Engineering—For Designers
November 15-19 (Philadelphia, PA)
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www.rawood.com/seminars
For a PDF course brochure, see:
www.rawood.com/ftp_files/
course_brochure_2003-3.pdf

Microwave Measurements for Digital Communication Systems
November 30-December 1 (Orlando, FL)
This course is held in conjunction with the 64th ARFTG Microwave Measurements Conference on December 2-3.
For further information, contact:
David K. Walker
NIST, M.S. 813.01
325 Broadway
Boulder, CO 80305
(303) 497-5490, FAX: (303) 497-3970
e-mail: dwalker@boulder.nist.gov
Internet: www.arftg.org

▸MEETINGS

ARMMS RF & Microwave Society Conference
November 1-2 (Rockingham, Corby, Northamptonshire, United Kingdom)
Hotel Elizabeth
For further information, contact:
J.J. Heath Caldwell—Marketing Coordinator
0845 0950 056
e-mail: jj@jjhc.co.uk
Internet: www.armms.org

APOC 2004
Asia-Pacific Optical Communications Conference and Exhibition
November 7-11 (Beijing, China)
Beijing International Convention Center
For further information, contact:
SPIE
P.O. Box 10
Bellingham, WA 98227-0010
(360) 676-3290, FAX: (360) 647-1445
Internet: www.spie.org/events/apoc

International Congress of Nanotechnology 2004
November 7-11 (Oakland, CA)
Oakland Convention Center
e-mail: events@ianano.org
Internet: www.nanoworldexpo.com

ASTM Committee B02 on Nonferrous Metals and Alloys
November 8-10 (Washington, DC)
For further information, contact Jeffrey Adkins, ASTM — (610) 832-9738
e-mail: jadkins@astm.org
Internet: www.astm.org/COMMIT/B02.htm

electronica 2004
November 9-12 (Munich, Germany)
New Munich Trade Fair Centre
Randi M. West, (312) 377-2650
Internet: www.munichtradefairs.com

ASTM Committee B10 on Reactive and Refractory Metals and Alloys
November 10-11 (Washington, DC)
For further information, contact Jeffrey Adkins, ASTM — (610) 832-9738
e-mail: jadkins@astm.org
Internet: www.astm.org/COMMIT/B10.htm

64th ARFTG Microwave Measurement Conference: Digital Communication System Metrics
November 30-December 3 (Orlando, FL)
Wyndham Resort
ARFTG, Inc.
P.O. Box 228
Rome, NY 13442-0228
Internet: www.arftg.org

2004 IEEE International Electron Devices Meeting
December 12-15 (San Francisco, CA)
The Hilton San Francisco
(301) 527-0900 ext. 103, FAX: (301) 527-0994
e-mail: iedm@his.com
Internet: www.ieee.org/conference/iedm

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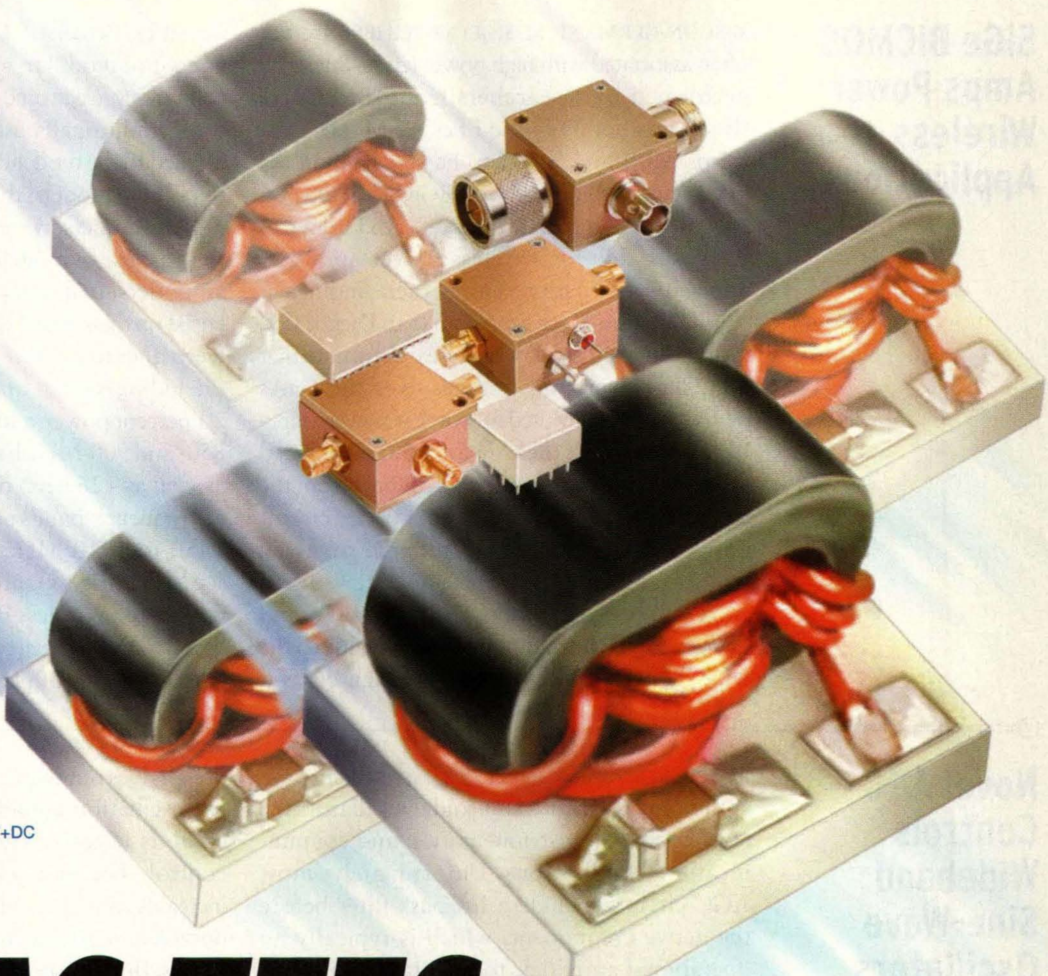

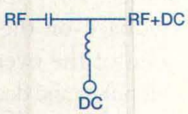

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SiGe BiCMOS Amps Power Wireless Applications

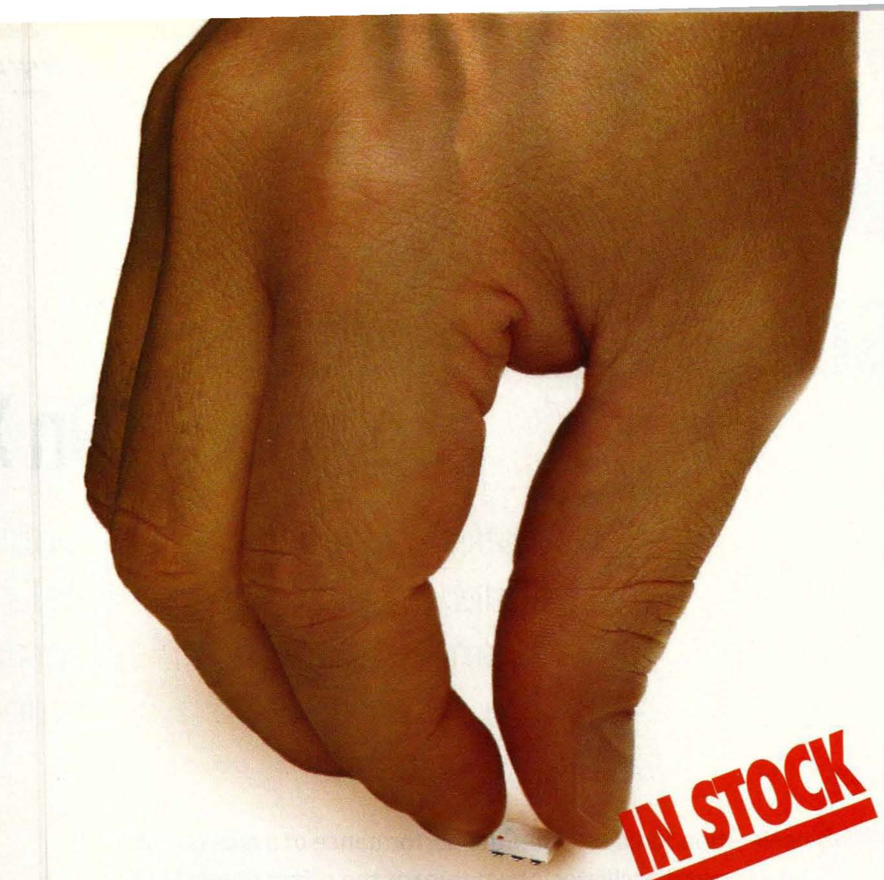
SILICON-GERMANIUM (SIGE) AMPLIFIERS are not often associated with high power levels. But work performed by researchers from IBM Corp. (Essex Junction, VT) and Ericsson Mobile Platforms AB (Lund, Sweden) has focused on the key device design issues for SiGe BiCMOS heterojunction-bipolar-transistor (HBT) devices to be suitable for wireless power-amplifier applications. First presenting their findings at the 2003 GaAs IC Symposium (San Diego, CA, November 9-12, 2003), the researchers note that SiGe has several advantages over the GaAs devices traditionally used for wireless power amplification. For one, the chip area can be reduced due to the excellent conduction of heat from the silicon chip to the silicon substrate; circuit design issues arising from thermal runaway issues are minimized by the temperature-insensitive current-gain behavior of SiGe HBTs; and devices can be further reduced in size due to the well-characterized reliability at high current densities. Because SiGe BiCMOS technologies consist of modular additions to a base CMOS technology, electronic-design-automation (EDA) tools traditionally used for CMOS can also be applied to the modeling of SiGe BiCMOS amplifiers. Two models, the HICUM and the MEXTRAM models, were found to be accurate for the purpose of modeling SiGe devices in power amplifiers. In developing circuits and modules based on their SiGe HBT devices, the researchers were able to achieve +27 dBm output power (including switch and modulator losses) and 20-percent power-added efficiency in the EDGE 850- and 900-MHz bands with a E-GPRS model as well as +26 dBm output power in the higher-frequency bands at 1710 to 1785 MHz and 1850 to 1910 MHz. For more information, see "Silicon-germanium BiCMOS HBT Technology for Wireless Power Amplifier Applications," *IEEE Journal of Solid-State Circuits*, October 2004, Vol. 39, No. 10, p. 1605.

Novel AGC Controls Wideband Sine-Wave Oscillators

AUTOMATIC-GAIN-CONTROL (AGC) schemes are commonly used with sinusoidal oscillators for level control in instrumentation and communications applications. Unfortunately, most AGC circuits include a lowpass filter before the active component, which is typically an operational amplifier, to maintain oscillation conditions. The inclusion of filtering of any kind will limit the available bandwidth of the AGC and the connected oscillator. To overcome this limitation of traditional AGC designs, An Sang Hou and Chin E. Lin from the Department of Electronic Engineering, Southern Taiwan University of Technology, Tainan Hsien, Taiwan, Republic of China have created a new AGC design based on the use of an up-down counter, multiplying digital-to-analog converter, and high-speed comparators. The new design does not require a lowpass filter to detect the oscillation amplitude. The overall system exhibits negative feedback on the loop gain control. The loop gain of the overall system increases with up-count pulses and decreases with down-count pulses, approaching unity. because of this, the complex roots of the overall system can be automatically corrected to the imaginary axis of the complex frequency plane, the oscillation amplitude can be stabilized, and the oscillation frequency can be varied over a wide operating range. The system can also serve as a low-distortion VCO. For more information, see "The New Design of AGC Circuit for the Sinusoidal Oscillator With Wide Oscillation Frequency Range," *IEEE Transactions on Instrumentation and Measurement*, October 2004, Vol. 53, No. 5, p. 1396.

Enhancing Bandwidth of Transimpedance Amplifiers

TRANSIMPEDANCE AMPLIFIERS (TIAS) are commonly used for signal processing in high-speed digital and optical communications systems. On the receiver side of these systems, a wideband amplifier is one of the most critical components in the signal-processing chain, especially with growing demand for increasing bandwidth capabilities. For this reason, Behnam Analui and Ali Hajamiri of the California Institute of Technology (Pasadena, CA) have developed a technique for bandwidth enhancement of a given TIA by adding several interstage passive matching networks. These additional stages enable the control of the amplifier transfer function and frequency response, achieving a 3-dB bandwidth of 9.2 GHz in their experimental TIA circuit design. The proposed CMOS design also exhibited transimpedance gain of 54 dBΩ in the presence of a 0.5-pF photodiode capacitance. For more information, see "Bandwidth Enhancement for Transimpedance Amplifiers," *IEEE Journal of Solid-State Circuits*, August 2004, Vol. 38, No. 8, p. 1263.



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ADE Mixers...Innovations Without Traditional Limitations!

ADE* TYPICAL SPECIFICATIONS:

MODEL	LO Power (dBm)	Freq. (MHz)	Conv. Loss Midband (dB)	L-R Isol. Midband (dB)	IP3 @Midband (dBm)	Height (mm)	Price ($ea.) Qty. 10-49
ADE-1L	+3	2-500	5.2	55	16	3	3.95
ADE-3L	+3	0.2-400	5.3	47	10	4	4.25
ADEX-10L	+4	10-1000	7.2	60	16	3	2.95
ADE-1	+7	0.5-500	5.0	55	15	4	1.99▲
ADE-1ASK	+7	2-600	5.3	50	16	3	3.95
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ADE-2ASK	+7	1-1000	5.4	45	12	3	4.25
ADE-6	+7	0.05-250	4.6	40	10	5	4.95
ADEX-10	+7	10-1000	6.8	60	16	3	2.95
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ADE-901	+7	800-1000	5.9	32	13	3	2.95
ADE-5	+7	5-1500	6.6	40	15	3	3.45
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ADE-11X	+7	10-2000	7.1	36	9	3	1.99▲
ADE-20	+7	1500-2000	5.4	31	14	3	4.95
ADE-18	+7	1700-2500	4.9	27	10	3	3.45
ADE-3GL	+7	2100-2600	6.0	34	17	2	4.95
ADE-3G	+7	2300-2700	5.6	36	13	3	3.45
ADE-28	+7	1500-2800	5.1	30	8	3	5.95
ADE-30	+7	200-3000	4.5	35	14	3	6.95
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ADE-35	+7	1600-3500	6.3	25	11	3	4.95
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ADE-1LHW	+10	2-750	5.3	52	15	3	4.95
ADE-1MH	+13	2-500	5.2	50	17	3	5.95
ADE-1MHW	+13	0.5-600	5.2	53	17	4	6.45
ADE-10MH	+13	800-1000	7.0	34	26	4	6.95
ADE-12MH	+13	10-1200	6.3	45	22	3	6.45
ADE-25MH	+13	5-2500	6.9	34	18	3	6.95
ADE-35MH	+13	5-3500	6.9	33	18	3	9.95
ADE-42MH	+13	5-4200	7.5	29	17	3	14.95
ADE-1H	+17	0.5-500	5.3	52	23	4	4.95
ADE-1HW	+17	5-750	6.0	48	26	3	6.45
ADEX-10H	+17	10-1000	7.0	55	22	3	3.45
ADE-10H	+17	400-1000	7.0	39	30	3	7.95
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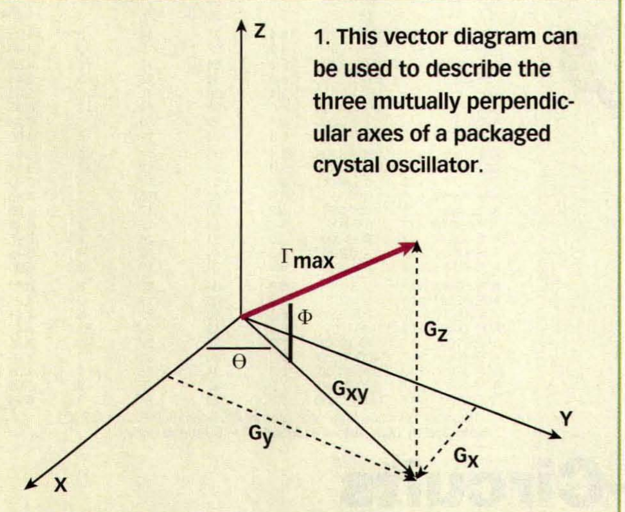
Size Up Acceleration Sensitivity On XOs

Acceleration force can shift or modulate the frequency of sensitive crystal resonators and oscillators unless proper steps are taken to absorb or compensate for vibrations.

STEVEN J. FRY
Development Engineering Manager
Greenray Industries, Inc., 840 West Church Rd., Mechanicsburg, PA 17055; (717) 766-0223 FAX: (717) 790-9509, Internet: www.greenrayindustries.com

Acceleration force can alter the performance of a quartz crystal or crystal oscillator. The nature of the effect depends on the type of force that is being applied. Changes in the static gravitational force such as tilting or rotation will cause a step offset in frequency. Time-dependent acceleration or vibration will create frequency modulation in an oscillator. This will generate discrete sidebands in the case of sinusoidal vibration or an increase in the noise floor with random vibration. A shock pulse will cause a sharp temporary perturbation in the output frequency. What follows is an examination of the effects of acceleration force on the performance of quartz crystals and crystal oscillators.

The magnitude of these frequency shifts is a function of the quartz crystal's acceleration or "g-sensitivity" vector and the magnitude and direction of the applied acceleration force. The acceleration sensitivity of quartz crystals is caused by stresses resulting from the mass of the resonator blank reacting against its mounting structure.[1] This sensitivity is determined by many factors such as the type of cut—such as stress compensated (SC) or AT, the design and processing of the quartz blank, the package type, mounting structure and orientation in the holder. The range of typical g-sensitivities for bulk-mode quartz crystals can span several orders of magnitude, from less than 1×10^{-10} per g for a carefully made precision SC crystal to greater than 1×10^{-7} per g for a low cost AT crystal.[2]



1. This vector diagram can be used to describe the three mutually perpendicular axes of a packaged crystal oscillator.

Since their magnitudes are relatively small, these effects go undetected in many applications with standard oscillators such as voltage-controlled crystal oscillators (VCXOs). With precision oven-controlled crystal oscillators (OCXOs) or sources designed for severe environmental conditions, the inherent acceleration sensitivity can be very significant. If the oscillator is deployed in a high-vibration environment such as an airborne platform, increased phase noise or discrete spurious components will appear as modulation on the output signal, degrading the performance more than all other sources of noise combined. Even in a benign environment, an OCXO may experience significant frequency shifts due to static g-forces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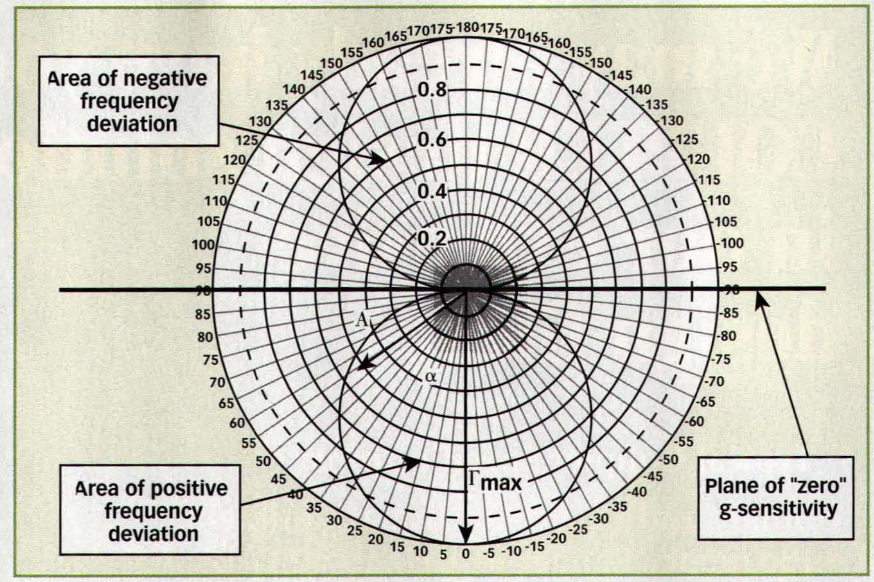


2. This plot shows the relative acceleration sensitivity of a crystal oscillator or resonator as a function of applied acceleration force.

by moving, tilting, or rotating motions.

A crystal oscillator's g-sensitivity is usually characterized by measuring the attributes along three mutually perpendicular axes parallel to the faces of the oscillator package. However, the intrinsic acceleration characteristic of quartz consists of a single vector at some angle that is usually not normal to any of the faces of the package **(Fig. 1)**. Therefore, the resonant frequency during acceleration is a function of the product of the two vectors:

$$F(a) = fo(1 + \Gamma \bullet a) \qquad (A)$$

where:

f_o = the center frequency of the resonator with no acceleration,

F(a) = the resonant frequency of the crystal with acceleration,

a = the applied acceleration, and

Γ = the acceleration sensitivity vector of the crystal.[3]

By measuring the individual mutually orthogonal components in the x, y, and z axes, the magnitude and orientation of the g-sensitivity vector, Γ_{max}, can be determined. Using the following trigonometric identities, Γ_{max} can be calculated without any prior knowledge of the crystal itself:

$$|\Gamma_{max}| = \left(g_x^{\,2} + g_y^{\,2} + g_z^{\,2}\right)^{05} \qquad (1)$$

$$|g_{xy}| = \left(g_x^{\,2} + g_y^{\,2}\right)^{0.5} \qquad (2)$$

$$\Theta = \arccos\left(g_x / g_{xy}\right) \qquad (3)$$

$$\Phi = \arcsin\left(g_z / \Gamma_{max}\right) \qquad (4)$$

Once the magnitude and angular orientation of Γ_{max} are known, the expected effect of externally applied acceleration forces in any direction can be determined. When the direction of the applied force is parallel to the axis of Γ_{max}, it will have the greatest influence on the crystal frequency. As the angle of the applied force moves away from the axis parallel to Γ_{max}, the resultant effect rolls off as the cosine of the angle α, which is defined as the difference between the direction of applied force and Γmax. For any direction of applied acceleration, the frequency shift is given as the product of the g-sensitivity vector, Γ_{max} times the applied force (A):

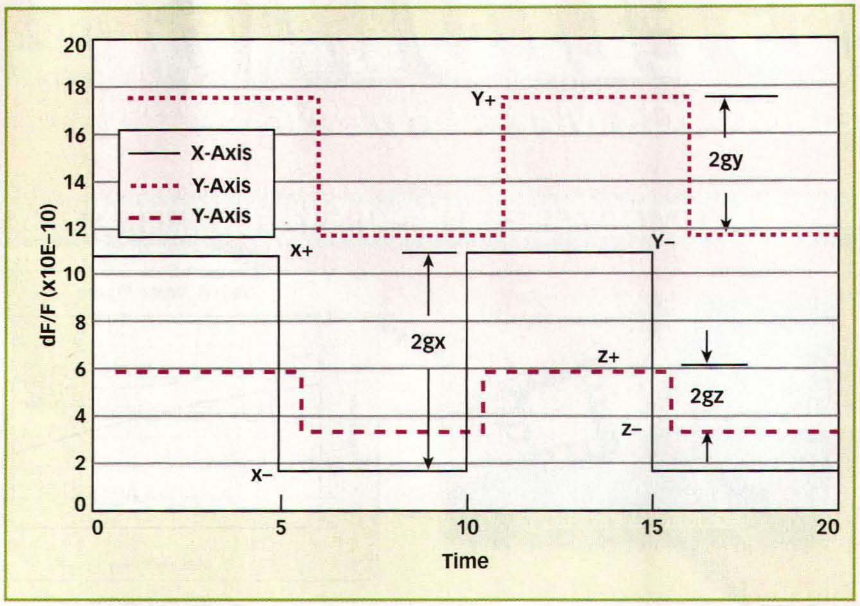
$$\Delta F / Fo = \Gamma_{max}(\Theta,\Phi) \bullet A(\Theta,\Phi) \quad (5)$$

Since the frequency deviation rolls off as the cosine of the angle α between A and Γ_{max}, a circle is defined as shown in **Fig. 2.**[4] If viewed in all three dimensions, this would appear as a sphere with Γ_{max} along its axis. Therefore, the resultant g-sensitivity of the crystal in any direction as a function of Θ and Φ can be given by:

$$g(\Theta, \Phi) = |\Gamma_{max}| \bullet \cos\Theta \bullet \cos\Phi \quad (6)$$

When the force is applied in the opposite direction, a frequency shift of equal magnitude but opposite sign is produced, defining the second circle in Fig. 2. Because of the vector and cosine nature of the g-sensitivity vector, an interesting attribute of this characteristic is that a plane of zero g-sensitivity is present. This is defined by the plane that is normal to Γ_{max}. This shows that any force applied to the crystal that is perpendicular to Γ_{max} will have no effect on the frequency. If the operating environment of the oscillator is such that the most severe acceleration or vibration forces are applied in one known direction, it is possible to orient the oscillator so that frequency shifts will be minimized.

Because of the relatively small frequency shifts that must be measured when characterizing a crystal oscillator's g-sensitivity, specialized test setups and high-resolution instruments are required. One of the most straightforward ways of making basic measurements on a precision oscillator is to use changes in the Earth's gravitational field to cause shifts in the oscillator frequency. This technique is known as the "2-g Tipover" method. The oscillator is placed in a fixture or on a bench and the frequency is monitored until it is stable. The unit is then flipped upside down or rotated 180 deg. and the frequency is once again measured. A unit initially experiencing a gravitational force of 1 g in the downward direction will be subject to a force of 1 g in the opposite direction after beng flipped. The net effect is a change of 2 g. Therefore, the amount of frequency shift measured divided by 2 is the oscillator's g-sensitivity in that axis. The procedure is then repeated for the other two axes. Although conceptually simple, the method requires an extremely stable oscillator to consistently measure the small frequency shifts that occur. Thermally induced short-term drift and modulation due to the connecting cables typically render this method invalid for uncompensated oscillators, although



3. The 2-g "tipover" test was used in evaluating a 12-MHz SC-cut OCXO.

it is used with OCXOs and tightly compensated TCXOs (Fig. 5).

In order to obtain a precision dynamic measurement, the performance of the crystal is measured while vibration is applied. When a crystal is subjected to sinusoidal vibration, the output of the oscillator will be frequency modulated with sidebands at the vibration frequency. The level of the sidebands may be determined with Eq. 7 using the standard frequency-modulation (FM) index formula (as long as the modulation index is relatively small).

Given that f_m equals the vibration frequency f_v and G is the peak applied vibration level, Δf is given by

$$\Delta f = G\Gamma f_{nom} \qquad (8)$$

which may be rewritten as Eq. 9.

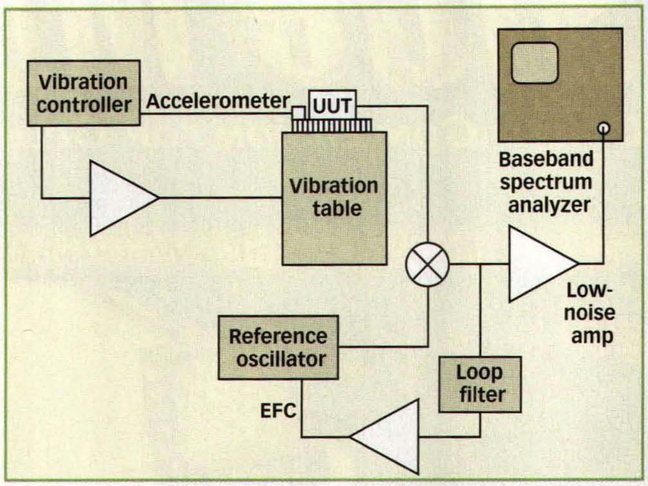
Using a high-dynamic-range, narrowband spectrum analyzer, it may be possible to measure these sidebands directly. If necessary, the modulation index and consequently the sideband levels may be increased by multiplying the frequency of the crystal. This will result in an increase of sideband level of 20logN where N is the multiplication factor. Measurement resolution can be improved by phase locking another oscillator to the device under test (DUT) to suppress the carrier signal. **Figure 4** shows a standard test setup for measuring vibration-induced effects, using a very sensitive low-noise phase-locked-loop (PLL) frequency discriminator.

To measure the vibrational characteristics of a resonator, the device to be tested is mounted on the vibration table in the proper orientation. The oscillator and crystal must be rigidly attached to the vibration fixture to avoid any mechanical resonance in the frequency range to be measured. The power leads and output cable must be held firmly in place with tape or glue to minimize the effect of vibration due to cable movement. In order to achieve the most accurate measurement of the g-sensitivity of just the crystal, it is necessary to remove the oscillator sustaining circuit from the vibration table so that only the crystal is exposed to the vibration. The connections are then made to the crystal through impedance-matched cables.[5] Apparent effects of including the sustaining stage on the vibrated assembly may be higher than 1×10^{-10}/g. To downconvert the oscillator's frequency to

$$\text{Sideband level (dB)} = 20\log(\Delta f / 2 f_m) \qquad (7)$$

$$\text{Vibration sidebands } (dB) = 20\log\left(G\Gamma f_{nom} / 2 f_v\right) \qquad (9)$$

baseband, the DUT is phase locked to a second reference oscillator at the same frequency. The baseband modulation present on the oscillator output as a result of the vibration is then measured with a low-frequency spectrum analyzer. This portion of the test set is typically a commercial phase-noise measurement system.



4. This phase-locked frequency discriminator can be used to measure vibration-induced effects in quartz-crystal oscillators.

While sinusoidal vibration generates discrete sidebands at the vibration frequency, the effects of random vibration are more complex, causing a general rise in the noise floor. By knowing the power spectral density (PSD) of the vibration input, it is possible to compute the g-sensitivity of the crystal from the resultant phase noise plot. The sideband formula given above is modified to use the PSD of the vibration input giving Eq. 10.

$$L(f) = 20 \log\left\{\left[(2PSD)^{0.5}\,\Gamma f_{nom}\right] / 2f_{vr}\right\} \quad (10)$$

Figure 5 shows the phase noise of a 100-MHz OCXO at rest and also with random vibration applied. Even moderate levels of random vibration can degrade the phase-noise performance of an oscillator by 40 or 50 dB. Mechanical resonances related to the crystal's mounting structure are often excited in the 1-to-4-kHz region and must be accounted for in critical applications

In some systems, the most prevalent type of acceleration is a short-duration shock pulse. These types of disturbances that can occur from handling and movement of equipment are often characterized as "microphonics." This type of event produces a momentary perturbation in the frequency of the oscillator as the resonant frequency of the crystal follows the applied force. After the shock pulse, the resonator should return to the original frequency unless the pulse was severe enough to cause damage to the mounting structure or circuit. If the oscillator is a reference in a narrowband PLL, this type of disturbance could cause the loop to break lock. This type of momentary excursion of the frequency is difficult to measure directly, but can be captured with a test setup using a digital storage oscilloscope (DSO). To measure this, the oscillator under test is mounted on a shock table. The unit is then phase locked to a reference oscillator or synthesizer. The error voltage is fed back through a loop amplifier and a wide bandwidth loop filter so that the loop will track the shock pulse even with a fast rise time. As a shock pulse is now applied to the unit under test, the frequency of the oscillator will shift in accordance with the magnitude of the shock pulse and the size and relative direction of the crystal's g-sensitivity vector. The g-sensitivity of the crystal in the direction of the applied pulse may be found by measuring the amplitude of the pulse developed on the automatic-frequency-control (AFC) loop voltage as recorded on the oscilloscope. The g-sensitivity (Γ) is determined according to

$$\Gamma = \left[A(Vp - p)S(ppm / V)\right] / SP(g) \quad (11)$$

where:

A = the voltage pulse amplitude,

S = oscillator tuning sen-

sitivity, and

SP = the level of the shock pulse.

Conversely, if the acceleration sensitivity of the crystal and the expected g-level of the shock pulse are known, the amount of frequency shift that will be experienced can be calculated.

Actual measurements of groups of crystals show that even with careful design and attention to details such as consistency of orientation and mounting, a large spread in the magnitude of the g-sensitivity vector as well as its direction is still present. When examining data (not shown) on the magnitude of the g-sensitivity vector for a group of 100-MHz fifth-overtone SC-cut crystals in TO-5 holders all supposedly manufactured under identical conditions, significant differences were still evident within the group.

Applications requiring the lowest acceleration sensitivity usually call for SC-cut crystals. The SC-cut crystal reveals an average Γ that is two to four times better than a similar AT-cut crystal at the same frequency. The AT-cut crystal, however, typically shows less variation in the distribution of both the magnitude and direction of Γ.[5]

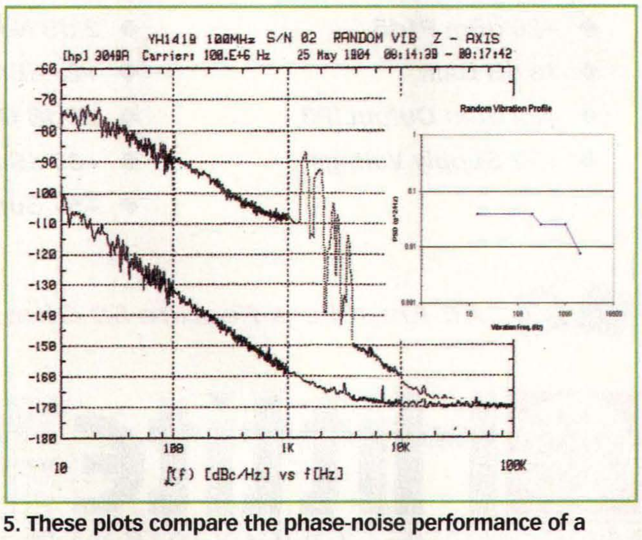
The direction of the applied acceleration force relative to the orientation of the g-sensitivity vector will have a large effect on the resulting frequency shift. If it is known that the most severe vibration or acceleration forces will be experienced primarily in one direction, it may be possible to orient the mounting of the oscillator to minimize the effects. After measuring the apparent Γ in each axis, the unit should be mounted if possible with the axis that has the lowest g-sensitivity parallel to the direction of the worst-case vibration. If the oscillator mounting structure can be rotated, the Γ vector may be pointed perpendicular to the applied vibration putting the assembly in the plane of "zero g-sensitivity." In real-world applications, all of the vibration and applied acceleration does not come from a single direction, so zero g-sensitivity will not be achieved, but improvements may be realized with the proper orientation.

Another method of reducing the detrimental effects of environmental forces is through the use of vibration and shock isolators to isolate the crystal and the sensitive portions of the oscillator circuit. To be most effective, the isolation system must be carefully designed, taking into account such factors as the frequency range and levels of the applied vibration, the weight of the isolated assembly and the spring factor characteristics of the isolators. The dynamic response curves of the transmissibility show that the isolation is only effective above the resonant frequency (f_n) of the system, which may typically be around 100 Hz. Below the resonant frequency, the vibration is

still passed to the crystal, and depending on the quality factor (Q) of the system, may exhibit significant amplification or peaking just below f_n **(Fig. 6)**. An isolated oscillator may need to undergo a sinusoidal resonant dwell vibration test, which can place great stress on the isolators. This could even lead to significant self-heating and eventual failure of the system.[6] Another concern is that the isolators be isoelastic so that the translational spring rates in all axes are the same, providing multiple-axis isolation with similar characteristics. Care must be taken in properly designing and specifying an isolation system, but this will usually provide considerable benefit in a harsh environment.

Another method to achieve g-sensitivity improvements involves applying active feedback from an accelerometer to compensate for or cancel the effects of vibration on the crystal. Several configurations have been reported which have achieved some significant improvements.[3,7] This technique consists of sensing the applied acceleration with an accelerometer and then amplifying and phase-inverting the sensing signal before applying it to an FM port on the oscillator. Specifications of the available accelerometers have improved over recent years making this approach more practical to implement. For complete cancellation, a three-axis accelerometer should be used with the sensitivity calibrated in each axis. Alternatively, a single axis accelerometer can achieve cancellation in all directions if certain conditions are met. The accelerometer must have a sensitivity that rolls off as $\cos\Theta$ when the direction of applied force moves away from its most sensitive axis. This matches the directional sensitivity of the crystal relative to G_{max}. The accelerometer must then be oriented such that its sensitive axis is pointing in exactly the same direction as the crystal's g-sensitivity vector.

To suppress vibration effects, it is necessary to accurately match the amplitude of the accelerometer signal to the sensitivity of the tuning port of the oscillator as well as the phase of the signal to the induced frequency shift of the crystal. The direction of the frequency shift must also be matched



5. These plots compare the phase-noise performance of a 100-MHz OCXO at rest and under vibration.

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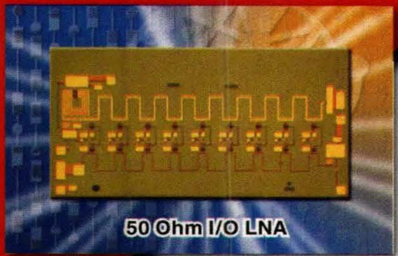

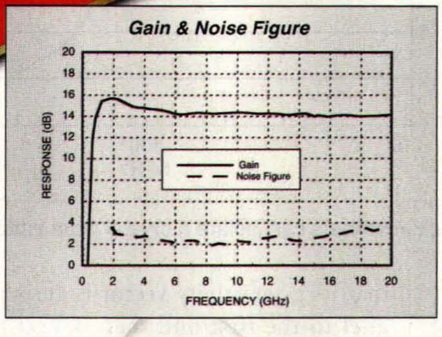

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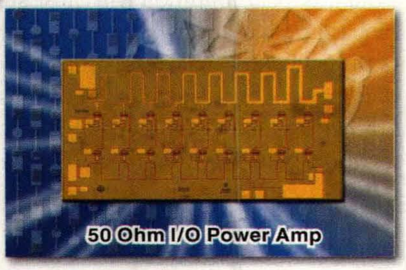

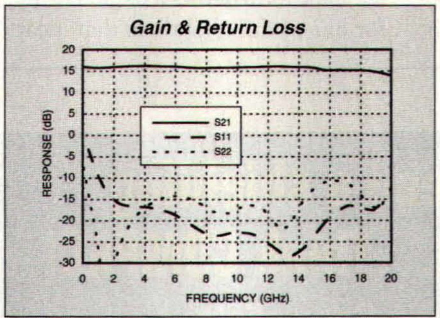

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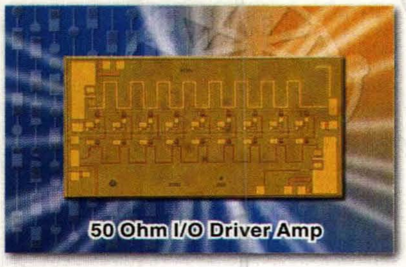

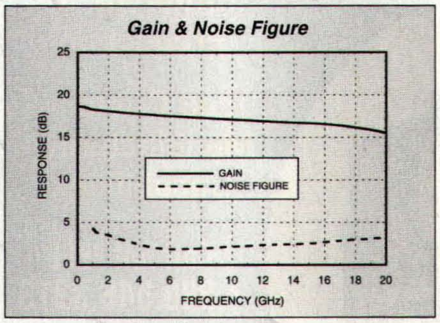

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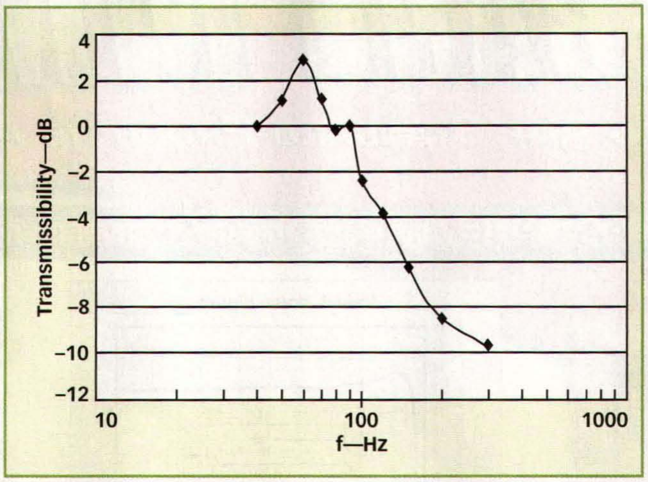
to the compensation signal. Without prior knowledge of the crystal vector direction, it is necessary to provide for inversion of the signal depending on the relative direction of the vector to the sensitive axis of the accelerometer. For suppression on the order of 40 dB, the amplitude must be matched to better than 1 percent and the phase to 0.5 deg. The compensation circuitry must be carefully designed and calibrated and must employ low-noise devices to ensure that the phase noise of the oscillator is not degraded.



6. Shock absorbers can isolate a crystal from vibration.

A passive method of canceling the effects of acceleration is possible by using a second crystal with a similar acceleration sensitivity vector.[8,9] Cancellation of the g-sensitivity can be achieved by orienting the second crystal such that its g-sensitivity vector is antiparallel to the first and then operating them in series in the same oscillator circuit. The crystals must be measured and oriented very accurately, requiring some form of two-axis gimbal mount for one of the crystals so that it can be rotated in three dimensions to line up with the crystal vector. Matching the direction of the two vectors to within less than 1 deg. can be difficult.

Many manufacturers of quartz crystals have attempted to reduce the acceleration sensitivity of the resonator itself. A perfectly symmetrical mounting structure relative to the active region of vibration on the quartz blank is critical. Other characteristics of the holder and mounting structure can also be significant.[10,11] Some special stress-free mounting arrangements have been proposed to achieve this goal.[12] Theoretically, if the crystal is completely symmetric with respect to the mode shape, the acceleration sensitivity can be zero. But even very small deviations from this ideal condition will cause significant degradation. The capabilities of the best commercial resonators, however, has not changed much in the past 20 years, with the best acceptable specification still being about 2×10^{-10} per g for screened SC-cut crystals. MRF

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Method Simultaneously Matches Inputs and Outputs

For the case of an unconditionally stable transistor, it is possible to simultaneously match the device's input and output ports to the load and source.

JOSEPH F. WHITE
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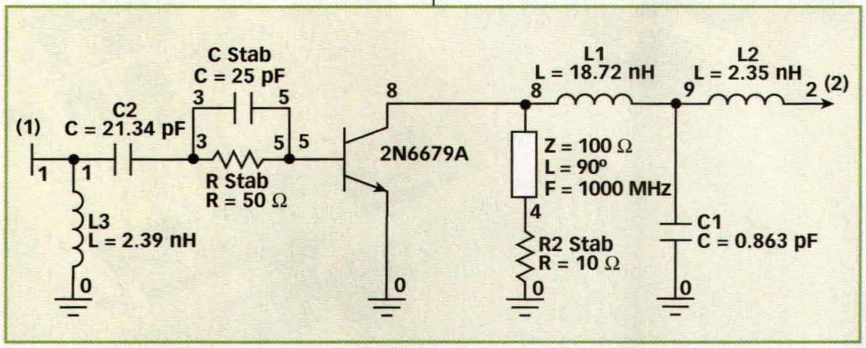
Engineers working on amplifier designs learned about the unilateral gain approach last month in Part 3 of this article series. That technique aims at simplifying amplifier design by providing an approximate solution, ignoring feedback in the transistor and with it the interaction of source and load impedances. This month, in Part 4, this amplifier design series will introduce a straightforward approach that achieves simultaneous conjugate matching of a stable transistor's input and output ports to its source and load.

The unilateral gain approach does arm the amplifier with a fairly simple and quick method for achieving high gain from a transistor. However, the need to design for stability requires the addition of input and/or output circuitry with the consequent need to perform arduous complex calculations of stability circles. Furthermore, addition of the stabilizing circuitry also requires recalculation of the S-parameters of the stabilized transistor. The result is that the design of a stable amplifier, even using the unilateral design method is very complex for hand calculation. While the necessary equations for hand calculation of amplifier design are provided in these articles, a circuit simulator or other software aid usually is desired to perform the considerable design labor involved in amplifier design.

Nevertheless, the unilateral design method is useful for providing initial insight into the various roles played by the input and output loads placed on the transistor. In fact, selection of these impedances constitutes the only RF circuit design options, after the choice of



1. This circuit is based on the use of simultaneous conjugate match for the input and output ports of the stabilized model 2N6679A transistor.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a candidate transistor. Given that suitable computer aid is necessary for comprehensive amplifier design, and having observed the effects of load interactions with the unilateral design, there is no further reason to ignore the feedback term S_{12}. Rather, it is appropriate to include it from the start in any amplifier design.

These impedances provide simultaneous input and output matching for the 2N6679A transistor

FREQUENCY (MHz)	Z_{SM} (Ω)	Z_{LM} (Ω)
900	2.879 +j8.446	59.433 + j154.129
1000	4.144 + j6.335	54.355 + j117.564
1100	8.872 + j4.838	35.046 +j100.924

The inaccuracies encountered by applying the unilateral design demonstrate that the feedback term, S_{12}, causes the value of the input impedance required for a perfect match to be affected by the load impedance and vice versa. It might seem that finding a simultaneous set of source and load impedances to match input and output perfectly would require an endless series of cut-and-try designs to arrive at the optimum set of Z_S and Z_L. But this is not the case.

For an unconditionally stable transistor (or an unstable one that has been stabilized), it is possible to find a *simultaneous conjugate match* solution yielding an amplifier design for which the input and output ports are perfectly and simultaneously matched to the load and source. This approach accurately takes the feedback due to S_{12} into account. This can be accomplished at any frequency for which S-parameters of a stable or stabilized transistor are available and provides the *maximum stable gain* (MSG) of which the transistor is capable at that frequency.

The solution[1] for the reflection coefficient, Γ_{SM}, to be presented by the source to the stable (or stabilized) transistor is

$$\Gamma_{SM} = C_1^* \left[\frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2|C_1|^2} \right] \quad (1)$$

where:

$$C_1 = S_{11} - \Delta S_{22}^* \quad (2a)$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \quad (2b)$$

$$\Delta = S_{11} S_{22} - S_{12} S_{21} \quad (2c)$$

At the output port, the simultaneous match load, Γ_{LM}, is given by

$$\Gamma_{LM} = C_2^* \left[\frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2|C_2|^2} \right] \quad (3a)$$

where:

$$G_{T\max} = \frac{\left(1-|\Gamma_{SM}|^2\right)|S_{21}|^2\left(1-|\Gamma_{LM}|^2\right)}{\left|(1-S_{11}\Gamma_{SM})(1-S_{22}\Gamma_{LM})-S_{12}S_{21}\Gamma_{SM}\Gamma_{LM}\right|^2} \quad (4)$$

$$C_2 = S_{22} - \Delta S_{11}^* \quad (3b)$$

$$B_2 = 1-|S_{11}|^2+|S_{22}|^2-|\Delta|^2 \quad (3c)$$

$$\Delta = S_{11}S_{22} - S_{12}S_{21} \quad (3d)$$

For an unconditionally stable transistor, the minus signs (where the option is ± in the above expressions produce meaningful results. When provided with Γ_{SM} and Γ_{LM} terminations, the transistor has its maximum gain,[1] G_{Tmax}, given by

SEE EQ. 4 IN BOX ABOVE

Interestingly, this gain expression, after some complex algebra, also can be written as

$$G_{T\max} = \frac{|S_{21}|}{|S_{12}|}\left[K-\sqrt{K^2-1}\right] \quad (5)$$

where:

K = the stability factor previously defined in Part 3.

The unilateral gain approach does arm the amplifier with a fairly simple and quick method for achieving high gain from a transistor.

When K < 1, the two-port is potentially unstable. At a given frequency, the MSG is a figure of merit for a transistor. However, it should be noted that when providing this gain, it borders on being conditionally unstable. The maximum stable gain occurs when K = 1. Then

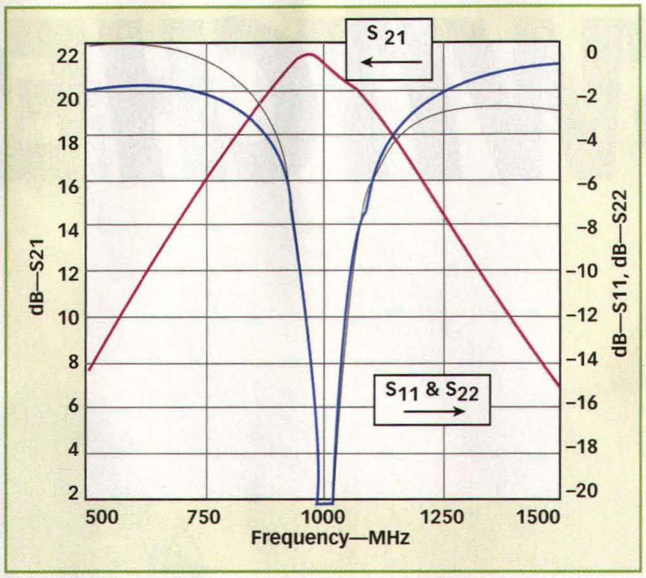
$$MSG = \frac{|S_{21}|}{|S_{12}|} \quad (6)$$

The MSG is easily calculated from the S-parameters, and transistor suppliers are fond of citing the MSG for their transistors, because it gives the highest applicable gain for the device. However, if operated with this gain, the device may be on the threshold of oscillation. Practical amplifier designers must back away from this

gain by a safe margin to ensure stability.

The computations of Γ_{SM} and Γ_{LM}, or the corresponding source impedance, Z_{SM}, and load impedance Z_{LM} are complex. However, these calculations can be performed using network simulation software. For the stabilized 2N6679A transistor, the results in impedance form are shown in the **table**.

The simultaneous conjugate match impedances, Z_{SM} and Z_{LM} are those that must be presented to the transistor at source and load respectively. One does not form the complex conjugates of these impedances. Notice that they are similar but certainly not identical to the Z_S and Z_L values used for the unilateral gain design.



2. This S-parameter performance data results from the simultaneous conjugate matched 2N6679A circuit of Fig. 1.

The source and load impedances at 1 GHz according to the unilateral design approach are $Z_S = 10.494 + j9.796\ \Omega$ and $Z_L = 88.493 + j46.646\ \Omega$. The source and load impedances at 1 GHz given by the simultaneous match design method are $Z_{SM} = 4.144 + j6.335\ \Omega$ and $Z_{LM} = 54.355 + j117.564\ \Omega$.

As an example of the application of the simultaneous match design to the stabilized 2N6679A transistor, the Q matching method of transforming the 50-Ω source and load to the required transistor load impedances was applied. The resulting matching circuitry is shown in **Fig. 1** while the performance for this circuit is shown in **Fig. 2**. The performance plots show that the input and output matches, S_{11} and S_{22}, exhibit return loss of 40 dB at 1 GHz, essentially providing perfect input and output matches. The

$$G_{T\,max} = \frac{|S_{21}|}{|S_{12}|}\left[K - \sqrt{K^2 - 1}\right] = \frac{6.25}{0.028}\left[1.151 - \sqrt{1.151^2 - 1}\right] = 129.7 = 21.1\ dB \qquad (A)$$

gain is 21.1 dB at 1 GHz.

The expected gain can be found from the magnitudes of S_{21} and S_{12} along with the K factor. At this frequency, the stabilized 2N6679 has $|S_{21}| = 6.25$, $|S_{12}| = 0.028$, and K = 1.151. Applying Eq. 5 yields

SEE EQ. A IN BOX ABOVE

This is also the value obtained from the circuit simulation of Fig. 1.

Maximum gain may not always be a critical performance requirement for a given amplifier design. For high-power amplifiers, for example, generous gain is important, but should also be achieved at the highest possible output power. This requires specifying a particular load impedance for the amplifier, a method corresponding to the *operating gain* design approach that will be presented next month in Part 5 of this amplifier design series. MRF

About the Author

Joseph White is a consultant and instructor. He received the Ph.D. EE degree from Rensselear Polytechnic Institute and has over 25 years of engineering experience. He published the textbook *High Frequency Techniques* (John Wiley & Sons, 2004) and teaches a one-week industrial course, *Wireless Engineering*, from which these articles are excerpted.

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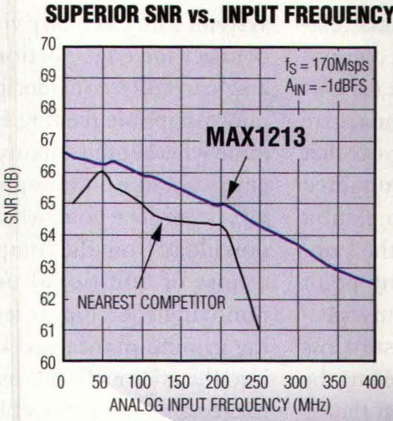

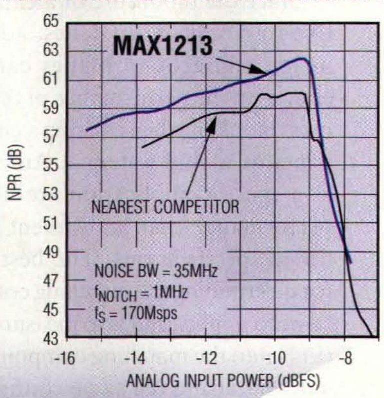

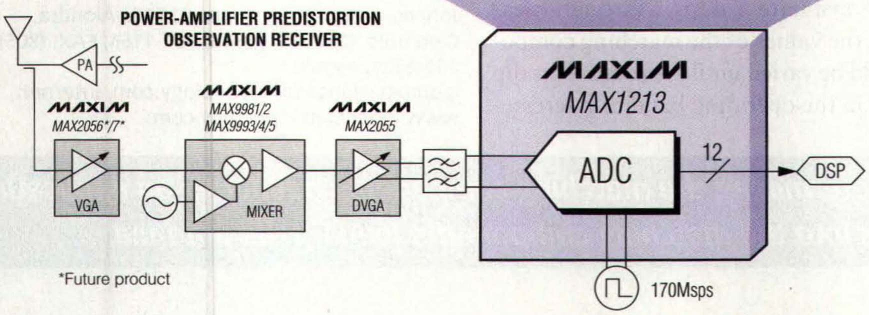

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Creating Layouts For WLAN Chip Antennas

EFFECTIVE DESIGN AND LAYOUT strategies can dramatically influence the performance of a chip antenna. Fortunately, an application note from Johanson Technology, "Chip Antenna Layout Considerations for 802.11 Applications," provides the essential details for creating an effective circuit layout including the chip antenna.

Since the mounting of a chip antenna relative to circuit mismatches, adjacent components, and ground planes can have serious effects on the performance of the antenna, care must be taken when creating a circuit layout that contains a chip antenna. Antennas mounted in a specific application are likely to exhibit performance that is different from the published specifications. The best starting point for determining the matching components needed in an application is to measure the return loss (S11) into the matching components feeding the antenna, using the same configuration that is planned for the final circuit layout. When it is possible to evaluate a design through measurements, the values of the matching components should be varied until the return-loss dip is centered in the operating band of interest.

The seven-page application note, written by Applications Engineer Ed Schoepke, provides numerous practical guidelines for creating an effective wireless-local-area-network (WLAN) circuit layout with a chip antenna, including considering the microstrip feeding the antenna to be part of the antenna resonance system; using as many via holes as possible to connect the edge portions of ground planes; and carefully considering the length of the microstrip line feeding the antenna to determine whether the antenna and connecting circuitry act like a monopole or a dipole antenna system. The note, which is available for free download from the company's website, offers a host of additional useful guidelines for removing the chip antenna from surrounding ground planes and keeping the feedlines into the microstrip line as perpendicular to the microstrip lines as possible. Several sample layouts are included.

Johanson Technology, Inc., 931 Via Alondra, Camarillo, CA 93012; (805) 389-1166, FAX: (805) 389-1821, e-mail: jpompey@johansontechnology.com, Internet: www.johansontechnology.com.

The best starting point for determining the matching components needed in an application is to measure the return loss into the matching components feeding the antenna.

Considering Broadband Circuits With ADCs And DACs

HIGH-SPEED CIRCUITS (above 1 GHz) designed for broadband use with analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) must include the effects of transmission lines for optimum performance. An application note from Atmel Corp. simply titled "HF Transmission" describes how to combine packaged ADCs and DACs with carefully chosen printed-circuit-board (PCB) materials and layouts to achieve maximum performance at high speeds.

The eight-page application note explains the role of the package in achieving good, high-frequency broadband performance. Using an 8-b, 1-GSamples/s ADC as an example, the literature examines the difference between ball-grid-array (BGA) and quad-flatpack (QFP) housings. Measurements find the first type of package to have better high-frequency performance than the second package, although the second package exhibits better thermal performance than the first. As a whole, the note explains that BGA packages shows better overall high-frequency performance than QFP housings and leaded packaged in general because of the low inductance of the connecting balls compared to the inductance of leads on leaded packages.

Given a packaged device, it is then a matter to properly mount the ADC or DAC on a PCB to obtain maximum performance within the surrounding circuitry. The key parameters in selecting a PCB include dielectric constant, loss tangent, temperature variations of the dielectric constant, and the coefficient of thermal expansion (CTE). Of course, for many applications, the cost of the PCB material is also an important consideration.

The eight-page note, which is available for free download from the company's website, provides tabular examples of PCB laminates and interprets the meanings of the materials parameters in terms of ADC and DAC performance. It also explores coupling and ground considerations and includes cost issues.

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cover story

EDA Software's Ease Of Use Belies Power

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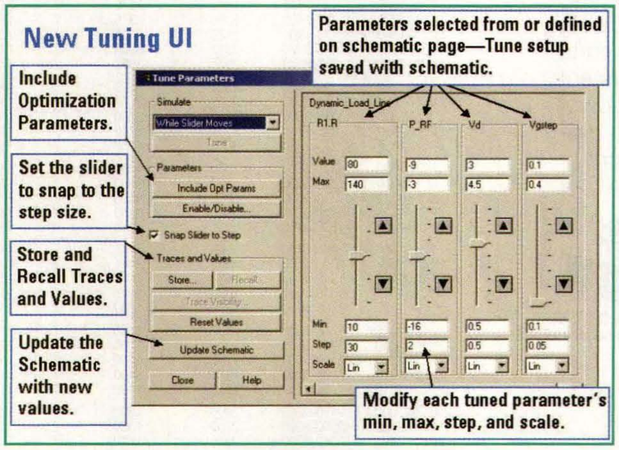
Although many features and functions have been added to the Advanced Design System (ADS) software suite, it has also been fortified with a simplified user interface.

Electronic-design-automation (EDA) software is a starting point for many high-frequency design engineers. Modern EDA tools can predict the performance of an RF/microwave component or circuit to within a fraction of a decibel but, like any software package, they must be relatively easy to use. In developing the next version of the popular Advanced Design System (ADS) suite of design tools, the design engineers and software developers at Agilent Technologies' Esof EDA Division recognized the need to combine improved circuit-design productivity with increased ease of use. The result is Agilent's ADS 2004A software, one of the most intuitive yet powerful releases of this well-known design suite.

The ADS software suite has long been recognized as an industry-leading design package for RF/microwave circuits. In all fields of product development, and particularly in software development, there is often a tension between making a tool powerful and making it easy to use.Creating a simple user interface in itself is no great engineering feat. The challenge lies in maintaining the engineering power of a complex platform like ADS under the control and access of a simple user interface.



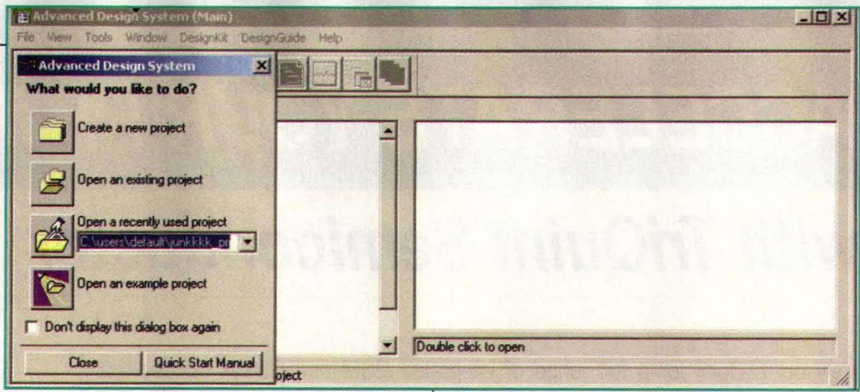
1. This is the new Advanced Design System (ADS) tuning user-interface. The greatly enhanced tuning capability delivers a 5× to 15× improvement in speed, providing real-time parameter tuning.

The latest version of ADS, Release 2004A, contains enhancements to its power and flexibility, but focuses on improving the ease-of-use for the most common design tasks, and providing an easier, more efficient design flow.

In EDA software, a key aspect of usability is the speed or responsiveness of the whole process. The user may not notice great improvements in linear simulation if the resulting data display time is increased, for example. Thus, this release of ADS focuses on the entire linear simulation process, from "simulation button down to data display up." The amount of overall improvement will vary according to the particular computer platform running ADS **(see table)**, with complex circuits in general showing the great-

est speed benefits and Windows XP personal computers (PCs) enjoying the greatest overall increase in simulation speed. Customers involved in the beta release frequently commented, "The overall product feels very responsive."

This latest release of ADS includes major enhancements to the tuning function. Again, speed improvement is an important usability factor. The 5× to 15× speed improvement provided by ADS 2004A results in true real-time tuning of circuits. The company offers an on-line demonstration of the ADS2004A's new features including this improved tuning speed at the link www.agilent.com/find/eesof-ads2004a-demo, while **Fig. 1** shows enhancements to the user interface that simplify the tuning function.



2. The new greeting dialog box comes up automatically when ADS 2004A is launched, with fast access to projects and a link to the quick-start manual.

ADS 2004A offers a new feature for snapping to a selectable step size while tuning. Tuning a circuit where the values of components can be varied with high resolution adds insight but yields impractical values. Setting the step size of a component's value and then snapping to these values when tuning improves the manufacturability of the circuit.

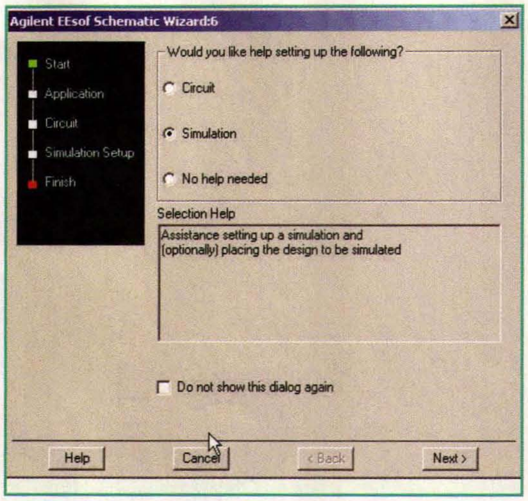
The tuning process was carefully considered when developing ADS 2004A. Improvements to the tuning interface deliver added functionality, such as making optimization parameters tunable with a single button click, and enhancements in the schematic window and data display improve productivity for the entire process. In addition to clicking on a component to make it tunable while the tuning interface is active, a component's tuning parameters (minimum, maximum, and step-size values) can be defined and saved on the schematic itself for improved efficiency. Adding legends to data display plots and displaying the values of the tuned components with each memory trace simplifies documenting and tracking the effects of a component

value on a circuit's performance.

A major enhancement to the ADS user interface is the addition of a greeting dialog and schematic wizard. Wizards are often included in consumer software to simplify common tasks. In ADS 2004A, the greeting dialog **(Fig. 2)** is automatically displayed when ADS is launched, giving quick access to projects and a link to the quick start manual. To set up a simulation in any EDA software, the designer is faced with a variety of questions concerning what type of circuit, whether or not it will include subcircuits, what type of simulation is needed, what sweep parameters are needed, and how the design should be set up on the schematic page. The new schematic wizard in ADS 2004A simplifies this process with a series of simple questions, resulting in a simulation-ready schematic and a sample circuit with which to get started **(Fig. 3)**.

The new schematic wizard guides designers through simulation setup by allowing designers to first choose the circuit type by application. Linear circuits, active device characterization, amplifiers, mixers, oscillators, and other application circuit choices are provided for setting up the simulation. Next, a list of sample circuits is provided or designers can choose an existing design. Finally, designers choose the sweep type, and the resulting schematic, complete with simulation and sample circuit, is displayed. The beauty of the wizard is that it preserves all of the power and flexibility of ADS, while simplifying the common steps involved in setting up a schematic for simulation.

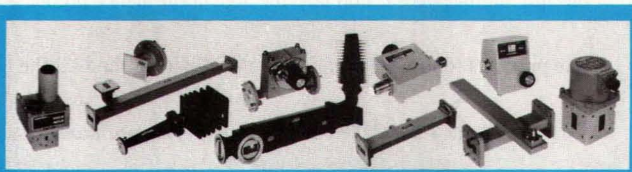
Usability, while the highlight of this ADS release, is accompanied by a number of other enhancements:

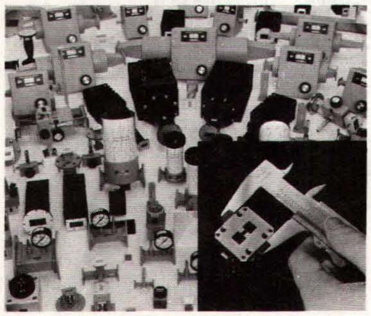


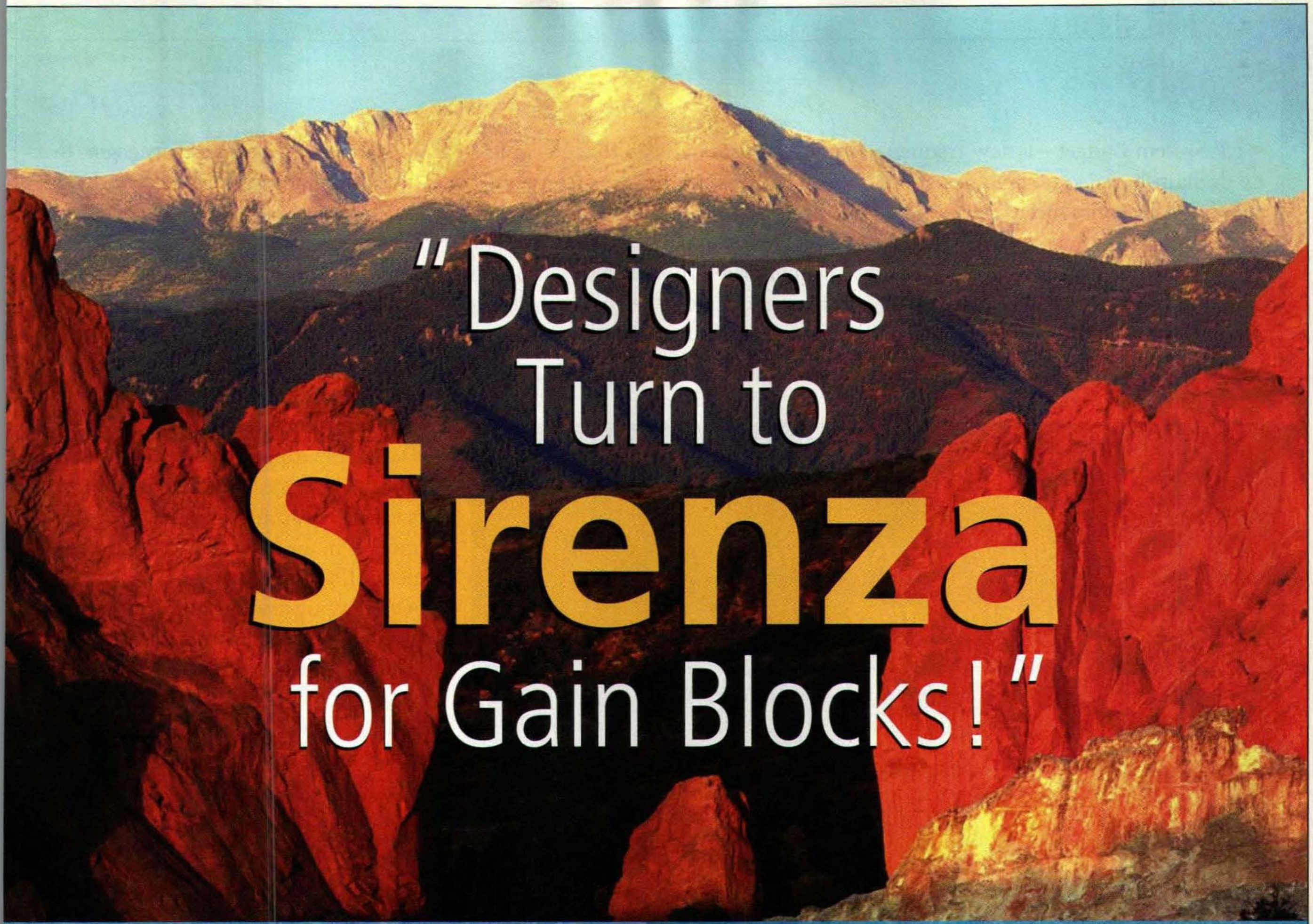
3. The new schematic wizard simplifies simulation setup resulting in a simulation-ready schematic and sample circuit with a few button clicks.

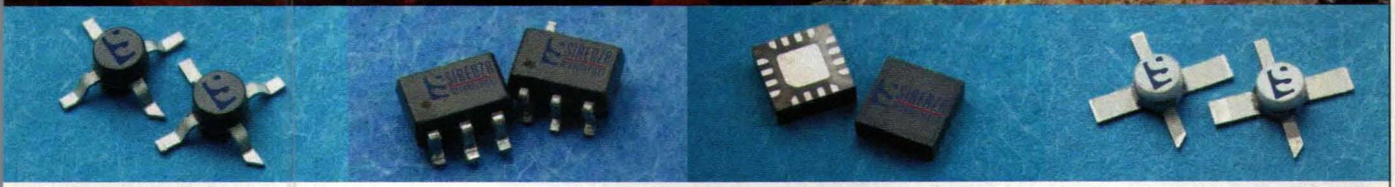
ADS 2004A shows marked improvements in speed compared to its predecessor, ADS 2003C

	Windows XP	LINUX	HP UNIX	SUN
Single component circuit	300 percent faster	10 percent faster	30 percent faster	80 percent faster
Medium circuits (100 to 200 components)	150 percent faster	20 percent faster	60 percent faster	20 percent faster
Complex circuits (>1000 component MMIC circuit)	750 percent faster	330 percent faster	250 percent faster	330 percent faster
Computer hardware	1.4-GHz PC, 768 MB RAM	1.4-GHz PC, 768 MB RAM	400 MHz, 512 MB RAM	450 MHz, 1 GB RAM









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• RF System Budget—a new frequency-domain-based system analysis tool that finds the component or subsystem that limits the performance of a design.

• Simulation improvements include automation of transient-assisted harmonic-balance simulations; improved phase-noise analysis that provides a single, accurate result; faster Krylov solver times when simulating oscillators; and improvements in memory management for more effective simulation of larger circuits when using the Direct Harmonic Balance simulator.

• A new physical connectivity engine that allows users to establish electrical interconnections based on polygonal-shaped layout artwork. The engine can extract interconnection information on the fly.

• Linux operating system support (RH 7.2, 7.3, and 8.0).

• New Wireless Test Benches provide linked sources and measurements for predefined wireless tests in ADS and the RF Design Environment software platform (from within the Cadence environment).

• Improved accuracy of the thick-metal models in the Momentum electromagnetic (EM) simulator.

• A new ultrawideband orthogonal-frequency-division-multiplex (UWB-OFDM) DesignGuide.

• An improved AgilentHBT transistor model, with self-heating effects.

• An improved Amplifier Behavioral Model, which includes multidimensional data for modeling under various temperature or bias conditions.

• A new Advanced Communications Model Set, which provides new Ptolemy, models for WLAN 802.11, WMAN 802.16, and UWB-OFDM.

• A new IBIS utility enables import of IBIS models for signal-integrity applications.

• Industry standard PC Installation.

• An improved Mixer2 RF system-level mixer model includes nonlinearity and noise characteristics.

• A new HSDPA-coded uplink source and base-station receiver supports bit-error-rate (BER) simulations.

The enhancements to ADS 2004A benefit new, occasional, and power users alike, by providing ease-of-use along with the depth needed to productively accomplish challenging design tasks. Agilent is encouraging customers to view the improvements in ADS 2004A by offering the chance to enter a weekly drawing for a combination 256M memory stick/mp3 player to anyone who views the demo available at www.agilent.com/find/eesof-ads2004a-demo. **Agilent Technologies, Inc., EEsof EDA Div., 1400 Fountaingrove Pkwy., Santa Rosa, CA 95403; (707) 577-4680, FAX: (707) 577-4620, Internet:www.agilent.com/find/eesof.**

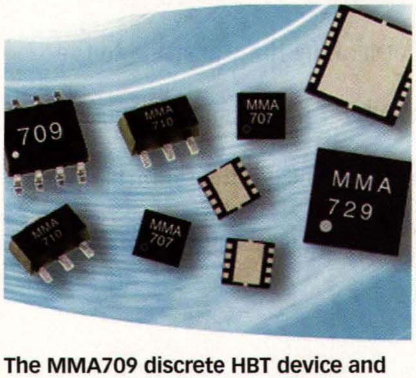
HBT Devices Deliver Gain/Linearity To 2.4 GHz

This family of discrete devices provides up to 4 W over moderate bandwidths with the linearity essential to wireless base-station amplifiers.

Linearity has become a driving requirement for wireless amplification, especially with the push toward more efficient bandwidth usage and more complex modulation formats. Discrete devices, such as the MMA709 heterojunction-bipolar transistor (HBT) from Aeroflex/Metelics (Sunnyvale, CA) provide the clean performance sought by amplifier designers, while also offering the flexibility of a discrete transistor. The HBT can achieve output levels to +33 dBm (2 W) over moderate bandwidths within the 100-to-2400-MHz range.

PETER SAHJANI
Vice-President of Marketing
Aeroflex/Metelics, Inc., 975 Stewart Dr., Sunnyvale, CA 94085; (408) 737-8181, FAX: (408) 733-7645, e-mail: sales@aeroflex-metelics.com, Internet: www.aeroflex-metelics.com.

The MMA709 **(see figure)** is a member of the company's growing line of indium-gallium-phosphide (InGaP) HBT-based discrete devices and monolithic microwave integrated circuits (MMICs) for commercial and military amplifier applications. These semiconductors compare favorably with other device technologies such as GaAs and silicon LDMOS in terms of cost while offering significant advantages in linearity.



The MMA709 discrete HBT device and the MMA712 InGaP gain block are the two latest members of a family of monolithic and discrete devices for high-gain, high-linearity commercial and military applications.

At present, model MMA709 is one of four devices available for applications through 2.4 GHz with varying performance levels. The devices are supplied in low-profile QFN-style 3 × 3-mm and 6 × 6-mm packages as well as industry-standard SOT-89 and SOIC8 housings. (The MMA709 is supplied in 3 × 3-mm QFN and SOIC8 packages.) Key specifications for all four devices are shown in the **table.** The MMA709 is characterized for Class A operation and is available in the "3030" and SOIC8 packages.

The MMA709 typically delivers 11 dB gain in the 1930-to-1990-MHz PCS band with +34 dBm associated output power and +54 dBm third-order intercept point when operating on 700 mA and +7 VDC. The third-order-intercept performance remains flat with frequency over the PCS band. The noise figure is 6.5 dB. The thermal resistance, as measured with an

infrared (IR) microscope, is less than 12°C/W.

In addition to the MMA709 discrete device, the company also launched its MMA712 gain block, with input and output ports matched to 50 Ω and resulting 3-dB bandwidth of 17 GHz.

The InGaP discrete HBTs at a glance

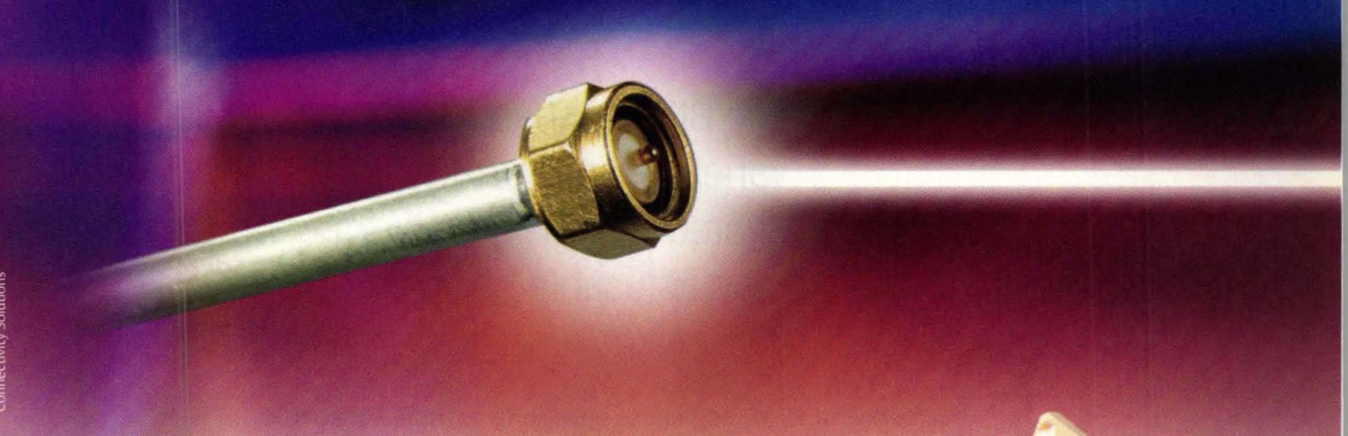
DEVICE	FREQUENCY (MHz)	GAIN (dB)	P_{1db} (dBm)	IP3 (dBm)	NOISE FIGURE (dB)	PACKAGE
MMA701	2110~2170	12	+27	+47	3.0	3030 SOT89
MMA707	2110~2170	11.5	+31	+50	6.0	3030 SOIC8
MMA709	1930~1990	11	+34	+54	6.5	3030 SOIC8
MMA729	430~470	18.5	+36.5	+56	7.0	6060 SOIC8

The gain block features typical gain of 12 dB from 1 to 18 GHz with output power at 1-dB compression of +11 dBm and input third-order intercept of +23 dBm. The noise figure is typically 5.5 dB. The gain block draws 48 mA nominal current from a minimum supply of +6 VDC.

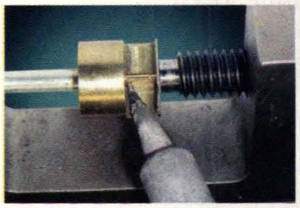
To address the need for high-reliability (Hi-Rel) vesions of these transistors and gain blocks, the firm has developed a program to cover screening per military (MIL) standards. The process features include eutectic die attach, gold wire bonding and hermetic, thermally enhanced packages. Devices are characterized over extended bandwidths and temperature ranges with maximum ratings that conform to JEDEC/IEC standards.

For example, JANTXV and JANS equivalent screening of package discrete devices is available in accordance with MIL-PRF-19500 and Class B and Class S equivalent screening is available for packaged MMICs in accordance with MIL-PRF-38535. Die are available with Class K and H die element evaluation in accordance with MIL-PRF-8534. The company also has a cost-effective screening program called COTS *Plus* for plastic encapsulated parts that incorporates all core screens and is applicable to the company's MMIC products. It includes 100-percent temperature cycling, thermal shock, burn-in at the maximum junction temperature, and full DC/RF testing. P&A: MMA709-30 (3030 pkg.) $11.22, 100 qty; MMA709-S8 (SOIC8 pkg.) $10.09, 100 qty. Both versions are available from stock. **Aeroflex/Metelics, 975 Stewart Dr., Sunnyvale, CA 94085. (408) 737-8181, FAX: (408) 733-7645, e-mail: sales@aeroflex-metelics.com, Internet: www.aeroflex-metelics.com.**

Maintain Reliable Connectivity Performance in Applications up to 40 GHz



SMK (2.92 mm) connectors, part of our **Johnson**® product line, give you reliable high frequency transmission when you need to go beyond the capabilities of SMA connectors. This array of stainless steel connector products includes cable plugs and field replaceable 2-hole flange, 4-hole flange and spark plug jacks. They use a smaller internal body diameter and air dielectric to achieve a higher cutoff frequency, and they typically hold return loss to –20 dB or less across the entire 0 to 40 GHz spectrum. All female contacts have a unique three-slot construction which enhances connectivity by creating a more rugged connection while reducing the chance of intermittent connections.



Our unique contact soldering tool holds extremely fine tolerances to help control impedance and maximize connector efficiency.

Precise tolerances minimize return loss, maximize transmission efficiency

Our SMK connectors are machined to extremely precise tolerances to provide uniform impedance control. In typical microstrip-to-coaxial applications, this helps minimize impedance differences to control return loss and maintain peak transmission efficiency.

These SMK connectors are backed by a precisely matched tooling set to assure excellent, repeatable contact and support bead location on cabled connectors. While some are familiar industry-standard tools, we've also developed unique devices that add unprecedented accuracy and reliability to field assemblies.

Contact Johnson® today by requesting our new SMK Catalog. Learn more about our full line of reliable high-performance SMK connector products. Call 1-800-247-8256. Or visit us on the web at www.emersonnetworkpower.com/connectivity.

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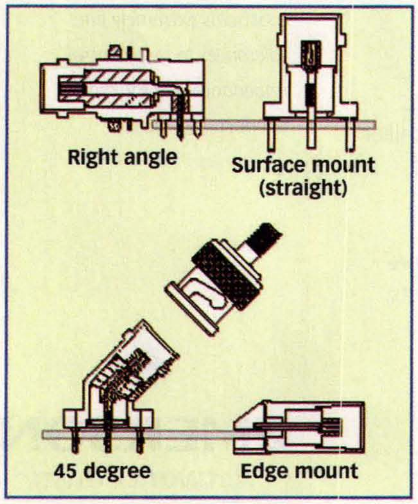
BNC Connectors Serve Microwave Needs

The BNC connector, which is available in a variety of configurations, has long been relegated to a frequency range much lower than its usable upper-frequency limit.

Microwave and RF engineers have long assumed that true high-frequency connectors, with the exception of blind-mate types, must have a threaded securing ring for a reliable ground connection. Because of this, the BNC connector has often been relegated to low-frequency applications in which S-parameter performance is not highly critical, and this type of connector has been limited to applications from DC to 2 GHz. In fact, the BNC connector is capable of higher-frequency performance, essentially the same performance level as its closely related, threaded sibling the TNC connector, with added benefits of comparably lower cost, easier connect/disconnect, and performance that holds up well against the universe of connector types.

DALE REED
Corporate Vice President, Sales and Marketing
Trompeter Electronics, 5550 E. McDowell Rd., Mesa, AZ 85215; (800) 982-2629, e-mail: dale.reed@trompeter.com, Internet: www.trompeter.com.



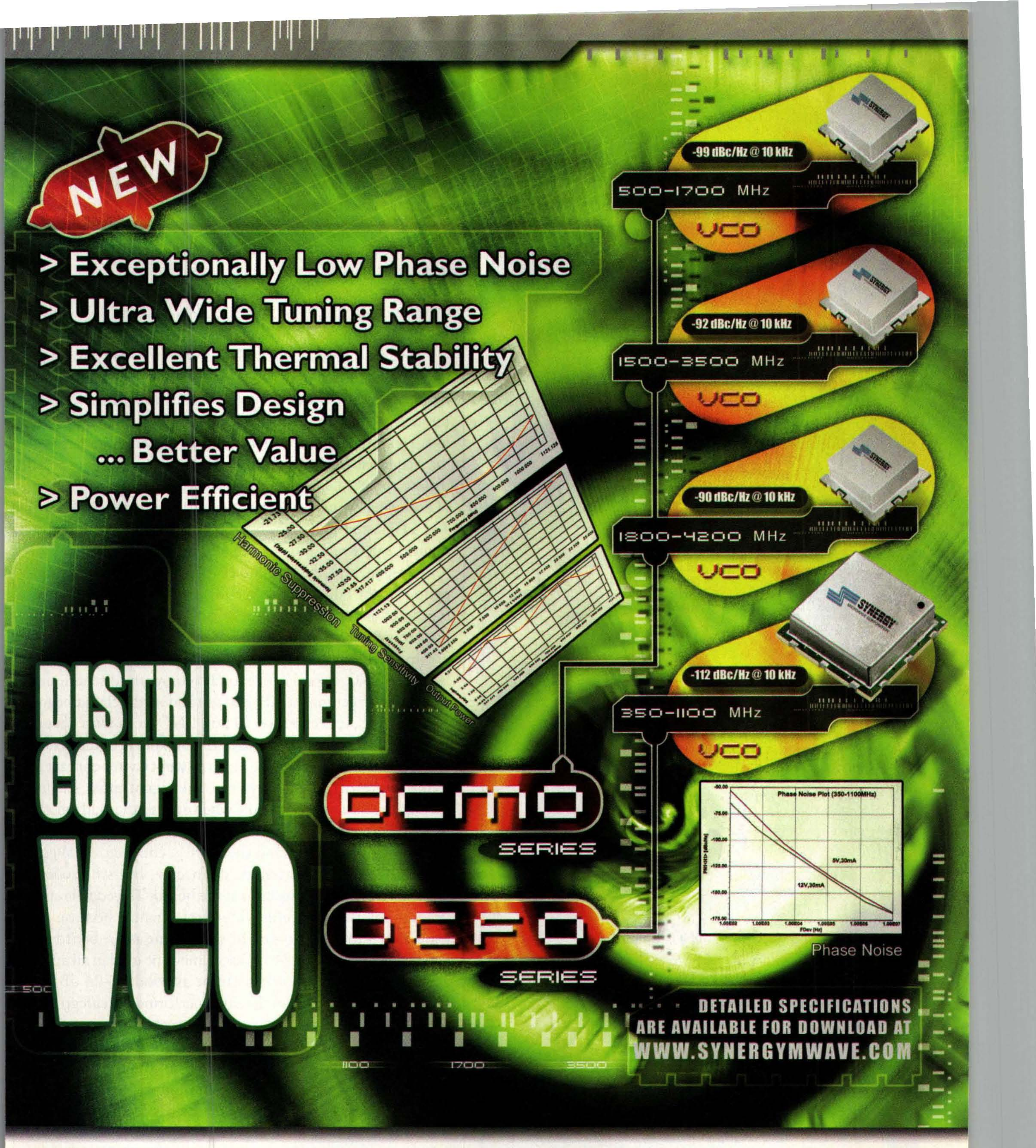
There are four basic types of BNC connectors for PCB mounting: 90-deg., surface-mount, 45-deg., and edge-mount types.

The BNC connector was developed in the United Kingdom in the early 1940s and named the Bayonet Neill Concelman (BNC) connector after the coupling mechanism and the names of the two inventors (it is at times wrongly called the British naval connector). The connector has a center pin connected to the cable conductor and a metal tube connected to the outer cable shield. A rotating ring outside the tube locks the cable to the female connector.

The way in which this simple design is mounted might suggest that, because there is some movement of the outer rotating ring after full engagement, the potential exists for degradation of the ground path between the male and female components. This is not true, however, since the rotating ring (or coupling sleeve) does not provide the primary ground connection, but is instead enabled by finger springs inside the connector jack. As a result, the rocking motion, which has been criticized in other "non-threaded" connectors as a possible source of ground interrupt, is of little or no concern with the BNC connector.

Typical printed-circuit-board (PCB)-mount BNC jacks have four legs for stabilization that carry the ground path from the surface of the circuit board to the body of the connector and a single pin for the center conductor. To simplify assembly, some more-sophisticated jacks feature an elongated center contact that facilitates fixing the jack into the PCB: the longer center pin is set in the hole, the part is rotated, and the other legs easily drop into place. In contrast, some simpler BNC jacks are designed with two separate parallel center conductor contacts. This approach permits undesirable crosstalk characteristics at higher frequencies and is not recommended for higher-frequency applications.

Return-loss performance, perhaps the single most important specification, varies significantly among BNC plugs and jacks. Return loss is influenced by the choice of dielectric material, the spacing of the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ground shield or interior of the connector body from the center contact, and the number and extent of abrupt transitions in impedance or geometry. The characteristics of the transition contribute most to return-loss characteristics. The solution to this is no different in a connector design than it is in general microwave circuit design: the smoother the transition, the better the return-loss performance. Sweeping the transition in a radius significantly improves this situation. In general, at 3 GHz and below, –20 dB is acceptable and –15 dB is marginal—the best BNC designs achieve return loss of –30 dB.

There are four basic types of BNC connectors for PCB mounting: 90-deg., surface-mount, 45-deg., and edge-mount types **(see figure)**. Some are better than others in reducing the severity of (or ideally eliminating) discontinuities that can increase return loss. This standard microwave problem is generally irrelevant at the frequencies to which BNC connectors are usually exposed (below about 1 GHz), but as frequencies increase the problem of abrupt right angles becomes a major consideration. Even at 4 or 5 GHz, the limit of the best BNC connectors, these discontinuities can significantly reduce return-loss performance.

Consequently, the best choice for higher-frequency applications is the edge-launch version. However, even 90-deg. types can deliver optimum performance if their center conductor is "swept" or curved rather than mitered or simply abruptly changed in direction by 90 deg. In fact, edge-launched BNC jacks almost entirely remove the discontinuity that occurs in getting the RF signal on and off the circuit board. Nevertheless, it is common to find BNC jacks with abrupt transitions from vertical to the horizontal plane of the board.

The right-angle connector uses a swept center contact to minimize return loss. However, the signal must still go through a 90-deg. transition when it hits the pad on the board. This is not remarkably better than the straight surface mount connector, and the 45-deg. connector is slightly better than the right-angle connector, but still doesn't address the 90-deg. transition at the board. The edge-launch version has the best return-loss performance because the transition into the jack is in the same plane as the board. Of course, edge-launched BNC jacks cannot be used in all applications, but their return loss can be as good as –26 dB at 4 GHz, which puts them in the same performance category as some of their more revered "precision" microwave counterparts. Nevertheless, through careful attention to providing a "swept" rather than abrupt center conductor, excellent return loss can be obtained even in right-angle types.

The properties that have made the BNC popular in networking applications have been largely overlooked by microwave engineers for applications to 5 GHz. Yet, the best BNC connectors are usable at these frequencies. The edge-launch BNC jack is extremely rugged, connecting as is does both above and below the board. Its "straight-on" design comes closest to making the jack all but transparent from the perspective of signal reflection. **Trompeter Electronics, 5550 E. McDowell Rd., Mesa, AZ 85215; (800) 982-2629, e-mail: dale.reed@trompeter.com, Internet: www.trompeter.com.**


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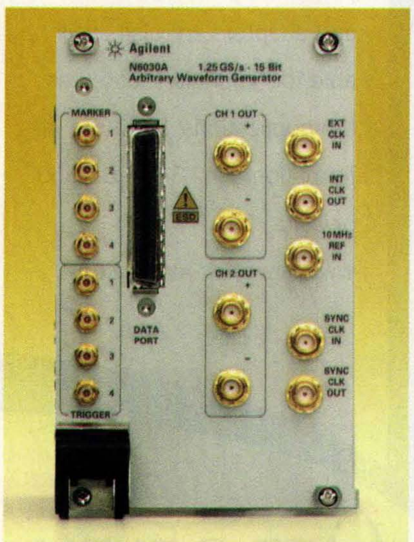
This arbitrary waveform generator can generate virtually any complex wideband waveform with 15-b resolution and sampling bandwidth to 1.25 GSamples/s

JACK BROWNE
Publisher/Editor

Arbitrary waveform generators (AWGs) offer almost unlimited flexibility in creating the most complex waveforms. Traditionally, such instruments have been limited in bandwidth and resolution, since they require the use of high-speed digital-to-analog converters (DACs). But the model N6030A AWG from Agilent Technologies (Palo Alto, CA) takes advantage of advances in DAC technology to offer 15 b vertical resolution with 1.25 GSamples/s sampling bandwidth. Housed in a four-slot 3U CompactPCI format, the AWG module achieves a spurious-free dynamic range of better than –65 dBc with 500 MHz of instantaneous analog bandwidth.



The N6030A arbitrary waveform generator features a 1.25-GSamples/s sampling bandwidth and 15-b resolution for generating a 500-MHz instantaneous bandwidth.

The N6030A (**see figure**) can be used as a stand-alone AWG or as a scalable system component for generating complex phase-coherent, multi-emitter scenarios. The digital source offers dual differential output channels to drive both single-ended and balanced designs. The instrument can be supplied with 8 MSamples standard memory for storage of arbitrary or complex waveforms, or 16 MSamples memory as an option. An advanced sequencing engine allows multiple waveforms to be combined into a complex signal streams with changing waveform characteristics. This sequencing engine also extends the effective size of the on-board memory. The N6030A can be used as an instantaneous-frequency (IF) in-phase/quadrature (I/Q) signal source for the company's PSG line of vector signal generators to achieve a 1-GHz I/Q bandwidth for wideband modulation at microwave frequencies.

A single N6030A module can drive eight total modules to create synchronous operation on a sample-by-sample basis. The module supports in-phase/quadrature (IQ) bandwidths to 1 GHz. The module is supplied with a complete software suite that aids developers in waveform file creation, transfer, and control of all module settings. It supports a variety of programming interfaces, including MATLAB®, LabView, IVI-C, and the Microsoft®.NET framework.

The N6030A can be used, for example, in conjunction with a digital storage oscilloscope (DSO). Waveforms sampled and captured with the oscilloscope can be downloaded to the memory of the N6030A and replicated with 15-b precision for use as test signals. P&A: $50,000 and up (N6030A) and $10,000 (memory option); 60 days. **Agilent Technologies, Inc., Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 829-4444 (item 7939), Internet: www.agilent.com/find/awg.**

GSA Test Plan Saves Government Buyers

By using GSA schedules to purchase electronic test and measurement equipment, federal agencies, the military, and select government contractors can cut their procurement costs.

JACK BROWNE
Publisher/Editor

Increasing military spending and expansion of homeland-security capabilities translate into greater need for electronic test and measurement equipment. For the test-equipment procurement taking place on the part of the US military, and by Federal and some state agencies, buying equipment through the General Services Administration (GSA) offers the opportunity to reduce costs while avoiding duplication of efforts in the procurement process. In particular, the GSA Schedules Program, which is also available though government pricing vendor sites such as TestMart (www.gsa.testmart.com).

The GSA Schedules Program was established on July 1, 1949, under section 101 of the Federal Property and Administration Services Act as the result of a Presidential Commission chaired by ex-President Herbert Hoover. The program establishes government-wide contracts with commercial firms to provide ordering offices with more than 4 million commercial services and products that can be ordered directly from GSA Schedule contractors or from the GSA Advantage (www.gsaadvantage.gov) online system.

Test equipment purchased through the GSA Schedules Program conform to the Federal Acquisition Regulations (FARs). Essentially, the GSA Schedules Program provides a long listing of available test gear (and other goods) with direct delivery and volume discount pricing. This includes a broad selection of RF and microwave test equipment.

Orders are considered issued using full and open competition. Ordering offices do not need to seek further competition, synopsize the requirement, make a separate determination of fair and reasonable pricing, or consider small business programs. By placing an order against a GSA schedule, the ordering office can conclude that the order represents the best value.

GSA schedule buying makes most sense for buying small quantities or single pieces, for commercial-off-the-shelf (COTS) items, and for equipment that is fairly standard (not custom). It makes less sense for those buying multiple quantities or more than $100,000, when buying against a particular specification, and when competitive bids (even for GSA products) are needed.

For those interested in GSA test equipment (without the other millions of items listed on the GSA Schedule Program), TestMart offers all relevant GSA test gear on their website. All GSA products are clearly identified by a special logo linked to explanatory text. GSA products are searchable by model, manufacturer, and category. **TestMart, 550 Taylor Ave., San Bruno, CA 94066; (650) 624-0525, FAX: (650) 624-0535, Internet: www.gsa.testmart.com.**

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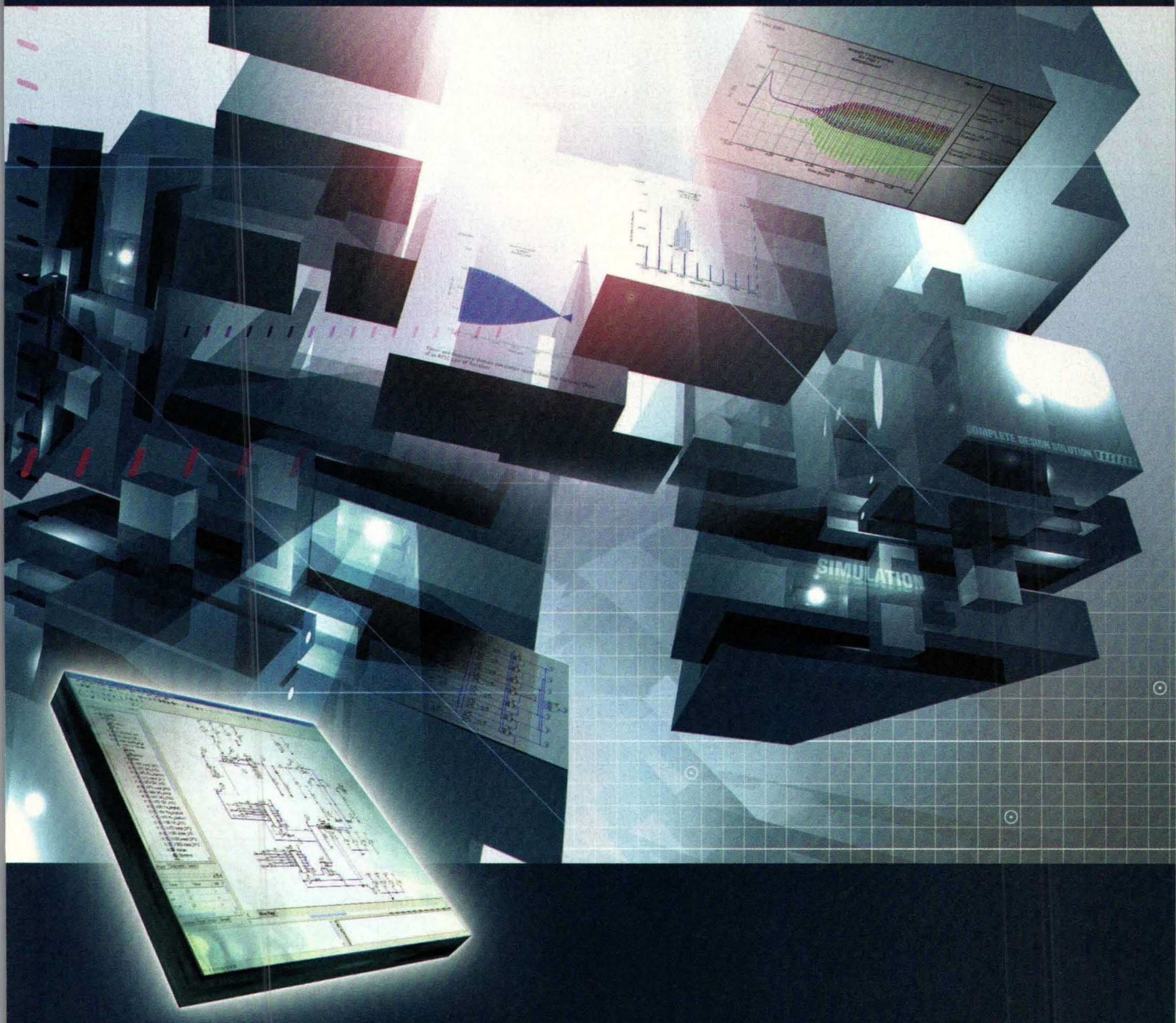

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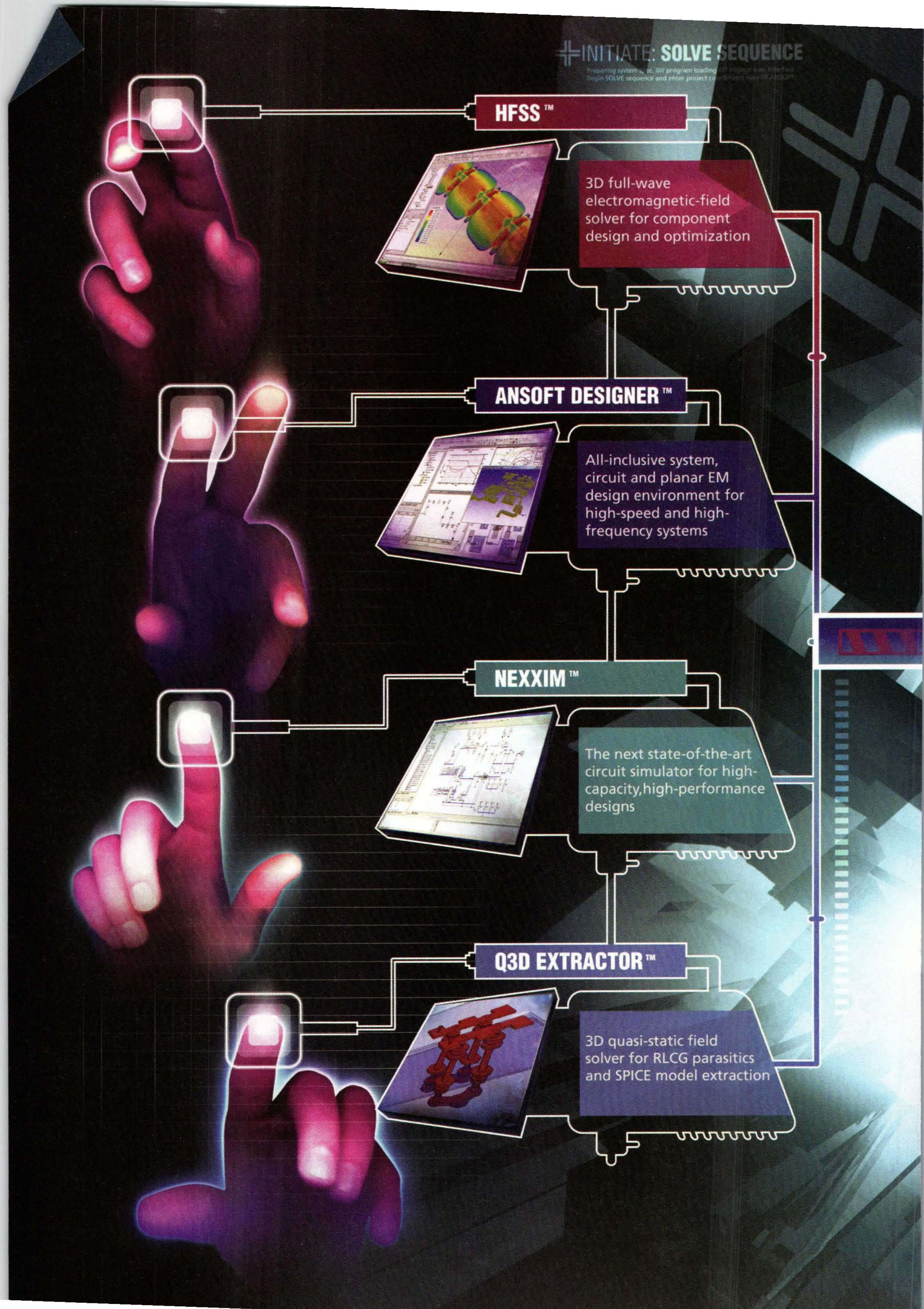

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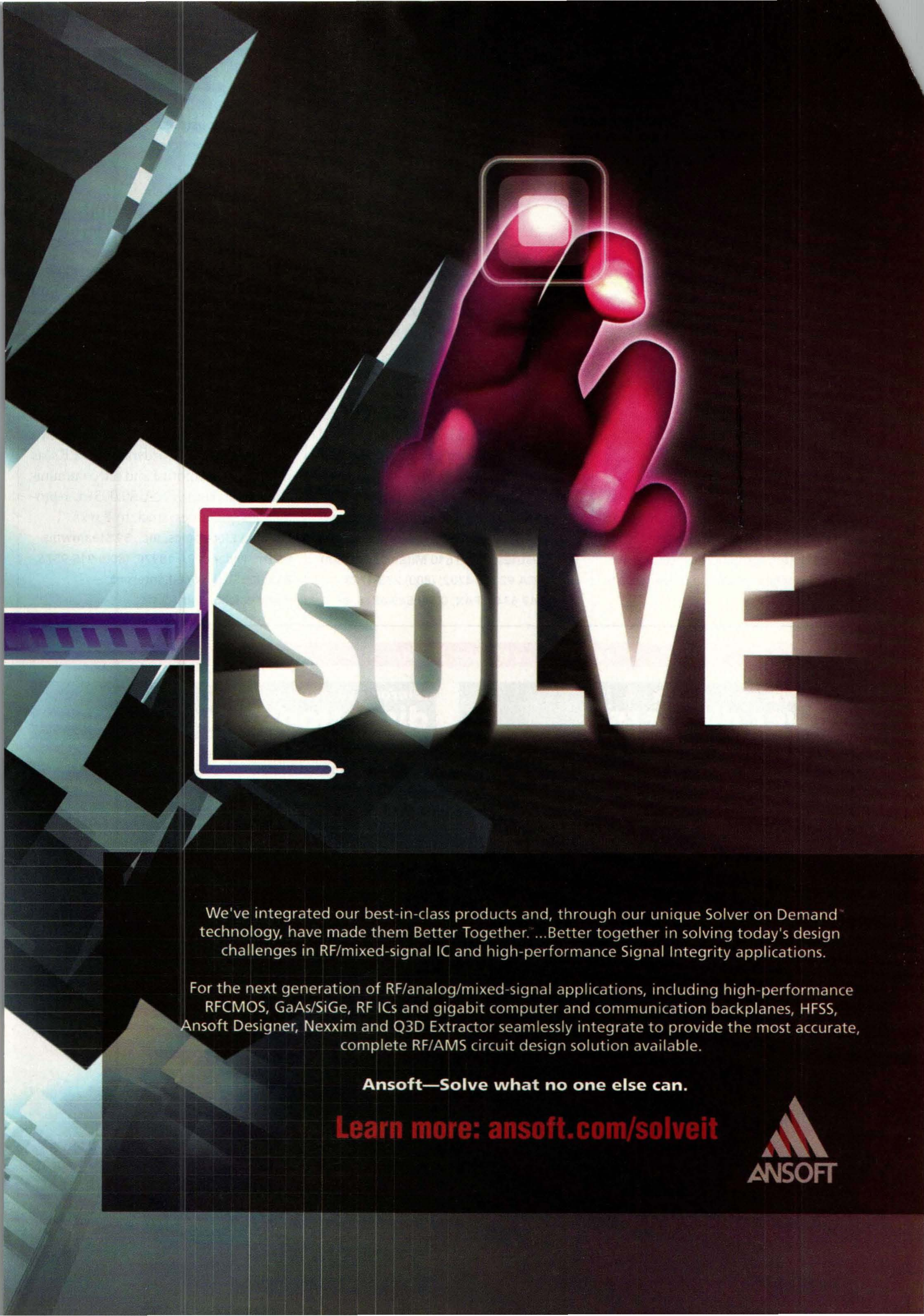
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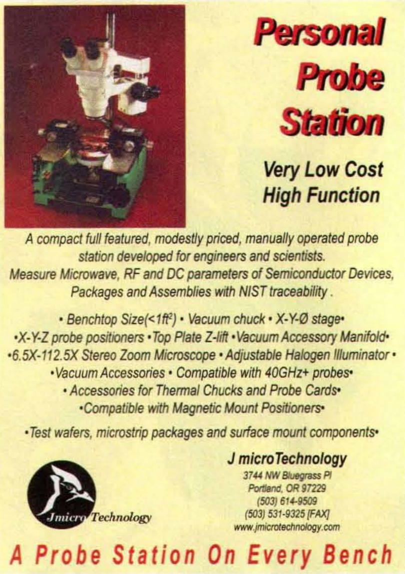

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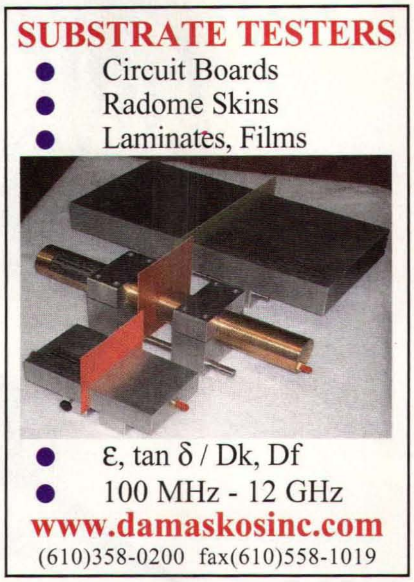

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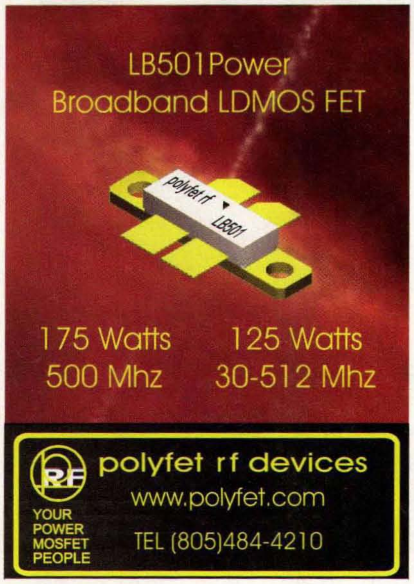

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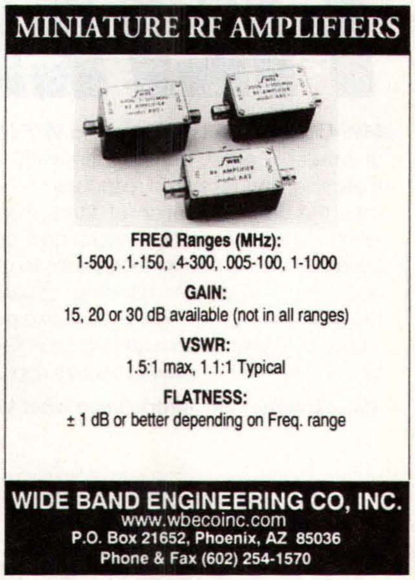

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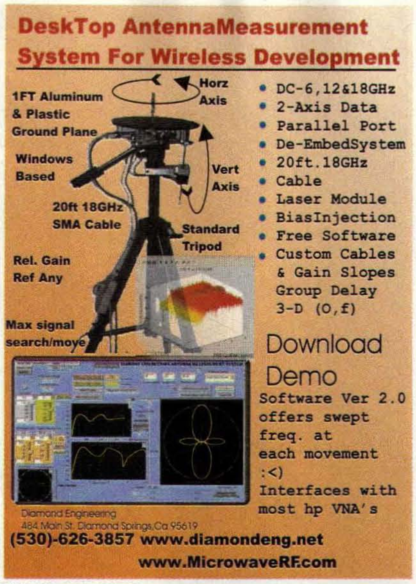

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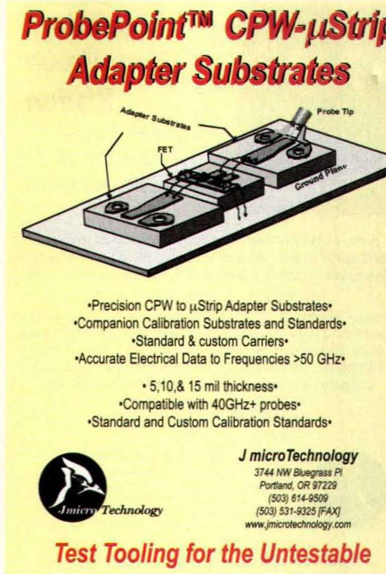

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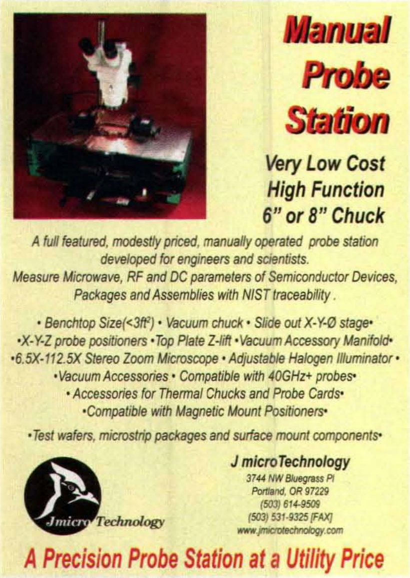

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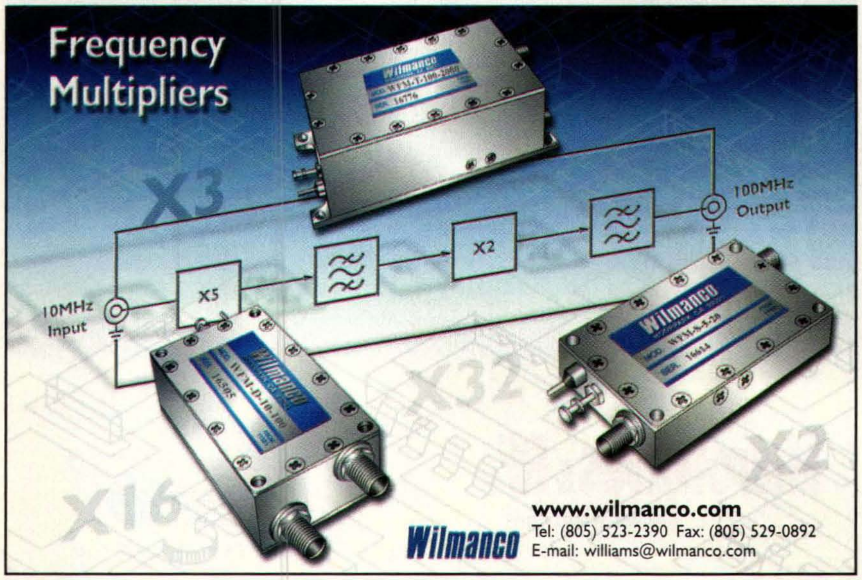

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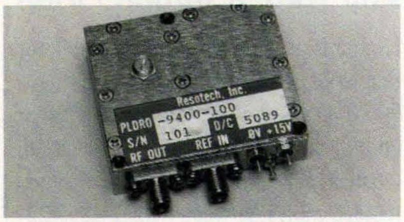

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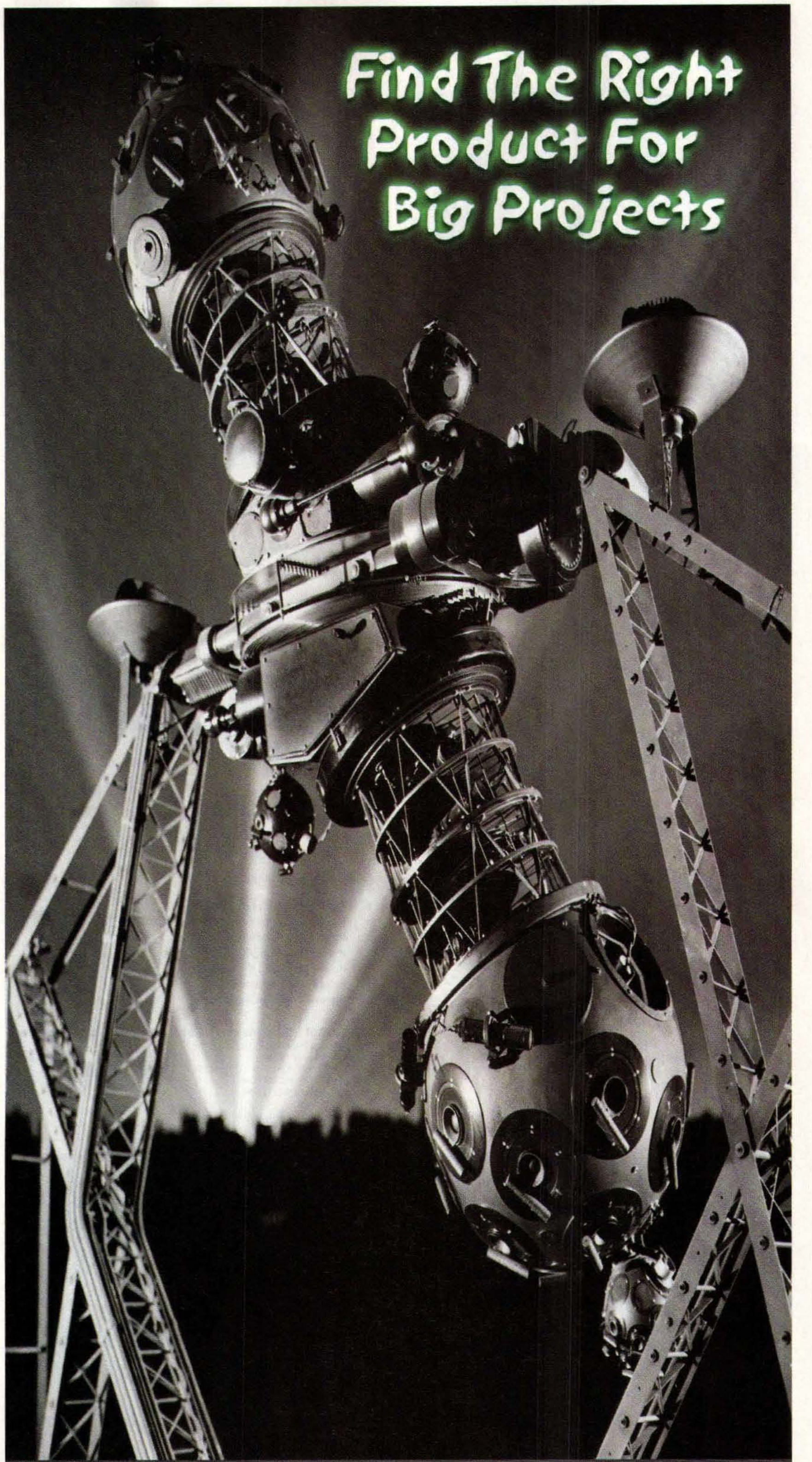

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looking back

NEARLY 22 YEARS AGO, then Associate Editor Barry Manz conducted an exclusive interview with two microwave pioneers, Dean Watkins and Dick Johnson, the founders of Watkins-Johnson Co. (now WJ Communications). Their first product was a low-noise traveling-wave tube (TWT), but many innovations and technical contributions followed.

next month

Microwaves & RF November Editorial Preview

Issue Theme: Computer-Aided Engineering

News

November marks a celebration of sorts, especially for the many who have contributed to the history of Merrimac Industries (West Caldwell, NJ). A Special Report will document Merrimac's 50 years of contributions to the microwave industry, from early single-function components for military systems to its current elegant Multi-Mix™ circuit fabrication technology for miniature multilayer circuits. The report will also highlight some of the more colorful personalities who helped build the Merrimac traditional. Also in the news section, a sneak preview of the hottest device breakthroughs to be announced at the upcoming International Electronic Devices Meeting (IEDM) in San Francisco, CA, December 13-15, 2004. (Those interested in attending can receive more information at www.ieee.org/conference/iedm.)

Design Features

November brings a variety of design techniques aimed at different portions of a microwave system. For example, authors from India explore techniques for coherent carrier regeneration from digitally modulated PSK signals, especially useful in remote-sensing SATCOM applications. Also, an author from Germany will describe how to create a VCO design capable of tuning 150 MHz around an 860-MHz center frequency. November also offers Part 5 of the transistor amplifier design series by Dr. Joseph F. White (on the concept of operating gain), as well as a detailed look at a unique RF DAC design that works with baseband DACs to eliminate antialiasing filtering (and group-delay distortion) in modulator systems.

Product Technology

November's Product Technology provides the first look at a second-generation radio chip set for EDGE handsets. Based on a fractional-N-synthesized phase modulator and predistorted linear amplification, the chip set promises reduced heat dissipation and increased battery life in GPRS and EDGE handsets. Additional Product Features in November include a flip-chip-mounted SP4T antenna switch for GSM applications, a 5.8-GHz transceiver design kit complete with fractional-N-synthesizer based transceiver, evaluation board, and software, a company's capabilities in thin-film design and fabrication, and a high-performance switched-oscillator bank for space applications.